# APPENDIX F

## ESTIMATION OF EXPOSURE OF PERSONS TO METHYL BROMIDE DURING AND/OR AFTER AGRICULTURAL AND NON-AGRICULTURAL USES

# ESTIMATION OF EXPOSURE OF PERSONS TO METHYL BROMIDE DURING AND/OR AFTER AGRICULTURAL AND NON-AGRICULTURAL USES

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# EXECUTIVE SUMMARY

Methyl bromide has been used extensively to fumigate soil, agricultural commodities, and structures in California. In 1995, all uses of methyl bromide amounted to 17.2 million pounds of active ingredient. Based on this amount, uses of methyl bromide for soil fumigation, commodity post-harvest fumigation, and structural pest control were 95.6, 1.4, and 3.0 percent, respectively.

This exposure assessment document was prepared as part of the Department of Pesticide Regulation's risk assessment process for methyl bromide. Adverse effects of methyl bromide, which were used to establish the endpoints for the critical no-observed-effect levels for risk assessment, were developmental toxicity (acute), neurotoxicity (subchronic), and nasal hyperplasia and degeneration (chronic). This document contains information, including physical and chemical properties, regulatory history, formulations, usage, label precautions, human illnesses, dermal toxicity/sensitization, animal metabolism, inhalation uptake and dermal absorption, and exposure assessment. Methyl bromide exposure estimates for workers and residents/bystanders were calculated from air concentrations of methyl bromide, and frequency and duration of exposures. Exposure estimates are reported as the 24-hour Time-Weighted Average (TWA).

Due to its high vapor pressure, the major route of exposure is by inhalation. Major excretion routes in rats after inhalation exposure occurred in exhaled air and urine. From 1991 to 1995, methyl bromide alone and methyl bromide in combination with chloropicrin caused 68 and 83 illnesses in California, respectively. From 1982 to 1995, there were accidental exposures where 231 people were evacuated. From the same period (1982-1995), there were 18 deaths resulting entirely from structural fumigation and all but two were from illegal reentry of locked, posted structures.

Exposure assessments for methyl bromide were grouped into 10 exposure scenarios. The average of acute exposure estimates (part per billion) calculated as the 24-hour TWA for these exposure scenarios are: 1) Preplant soil injection fumigation, 0.6-835; 2) Soil fumigation in nurseries and greenhouses, 1-562; 3) Fumigation of grain products, 6-6,039; 4) Dried fruit and tree nut fumigation, 0.4-13,281; 5) Fumigation of cherries for export, 11-327 (compliance monitoring study at dump stations, 18); 6) Worker exposure and on-site air monitoring studies at a walnut processing facility, 2-4,100 (compliance monitoring study in work areas, 28-479); 7) Space-type fumigation at a brewery facility, 25-173; 8.a) Residents/bystanders (air concentrations near fumigated single-family houses), 24-522; 8.b) Residents/bystanders (downwind air concentrations during aeration of fumigated single-family houses), 40-296; 9) Resident exposure to methyl bromide during reentry into treated houses, 210 (default); 10) Exposure of residents to methyl bromide during commodity fumigation, 210 (default). Many of these studies were conducted prior to the implementation of permit conditions/regulations and may not reflect exposure after restrictions were implemented; these studies were soil fumigation, nursery potting soil fumigation, greenhouse soil fumigation, fumigation of grain products, fumigation of dried fruit and tree nut products, fumigation at a walnut processing and a brewery facility, and fumigation of houses. The Department of Pesticide Regulation does not have data to assess all worker exposure scenarios or potential exposure to the public from all methyl bromide applications.

Non-acute exposures (7-day, 90-day, and 365-day exposure periods) were also estimated for different work tasks and exposure scenarios. These exposures were estimated from acute exposure, and frequency and duration of exposure for each specific exposure scenario.

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METHYL BROMIDE

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## INTRODUCTION

Methyl bromide (MB) is widely used as a fumigant to control pests in soil, fresh and dry agricultural products, residences and other structures. This fumigant is acutely toxic to humans from excessive inhalation exposure. Steps were taken in California in the past several years to reduce potentially harmful exposures to users and residents/bystanders. These steps included issuing new and more restrictive permit conditions, establishing buffer zones, modifying application equipment, and increasing aeration time for fumigated structures. Currently, the Department of Pesticide Regulation (DPR) is working on the risk assessment of MB under the provision of the Birth Defects Prevention Act of 1986 (SB 950). The Worker Health and Safety Branch (WH&S) is responsible for the preparation of the MB exposure assessment document, which is an integral part of the risk assessment process.

Many exposure monitoring studies were conducted prior to the implementation of permit conditions/regulations and may not reflect exposure after restrictions were implemented; these studies were soil fumigation, nursery potting soil fumigation, greenhouse soil fumigation, fumigation of grain products, fumigation of dried fruit and tree nut products, fumigation at a walnut processing and a brewery facility, and fumigation of houses. The Department of Pesticide Regulation does not have data to assess all worker exposure scenarios or potential exposure to the public from all methyl bromide applications.

The exposure assessment document contains sections dealing with physical and chemical properties, regulatory history, formulations, usage, label precautions, human illnesses, dermal toxicity/sensitization, animal metabolism, inhalation uptake and dermal absorption. Information from these sections contributes better understanding of the nature, usage, and potential for exposure. Exposure estimates are presented as the 24-hour time-weighted-average (TWA) air concentration of MB. These estimates are grouped as acute exposure (daily exposure) and non-acute exposures (subacute, subchronic, and chronic exposures).

## PHYSICAL AND CHEMICAL PROPERTIES

Physical and chemical properties of MB as mentioned below were obtained from the Farm Chemicals Handbook (Meister, 1995), the Merck Index (Budavari *et al*., 1989), and United States Environmental Protection Agency (U.S. EPA, 1986a).

Chemical name: Bromomethane, monobromomethane
CAS Registry number: 74-83-9
Common name: Methyl bromide
Trade names: Brom, Brom-O-Gas, M-B-R, Metabrom, Meth-O-Gas, Methyl Bromide, Pic-Brom, Terr-O-Gas, Tri-Brom, Tri-Con, Tri-Pan.

Molecular formula: $CH_3Br$
Molecular weight: 94.95 g/mole
Chemical structure: $CH_3$-Br
Physical appearance: Colorless gas, usually odorless; sweetish, chloroform-like odor at high concentrations (odor threshold at 80 mg/$m^3$ or 20.6 ppm); burning taste. It is non-flammable in air but does burn in oxygen.
Solubility: 1.75 g/100 g water (20 $^oC$, 748 mm Hg), forms a crystal hydrate, $CH_3Br.20H_2O$, below 4 $^oC$; freely soluble in alcohol, chloroform, ether, carbon disulfide, carbon tetrachloride, benzene.
Boiling point: 3.56 $^oC$
Melting point: -93.66 $^oC$
Octanol/Water partition coefficient: Log P = 1.19 (15.5:1)
Vapor pressure: 1420 mm Hg (20 $^oC$), 2600 mm Hg (40 $^oC$)
Specific gravity: 1.7 g/mL (liquid)
Vapor density: 3.3 g/L (gas)
Conversion factor: 1 ppm = 3.89 mg/$m^3$ at 25 $^oC$

## REGULATORY HISTORY INCLUDING U.S. EPA STATUS

The insecticidal activity of MB was first reported in 1932 (Le Goupil, 1932). MB is a restricted use pesticide in the United States. Retail sale and use are limited to certified applicators or persons under their direct supervision, and only for those uses covered by the applicator's certification.

### Ozone depletion

1. MB is an ozone depleter with a calculated ozone depletion potential (ODP) of 0.7 (Watson *et al.*, 1992).
2. The world-wide sources of MB include: Anthropogenic (human made) agriculture, biomass burning (forest fires, grass fires), leaded gasoline burning, and oceans.
3. U.S. Clean Air Act mandated that by the year of 2005, no production or importation of MB is allowed. However, the Act does not restrict the use which is regulated under the Federal Insecticide, Fungicide and Rodenticide Act in the U.S. EPA, Office of Pesticide Programs.
4. At the 1997 meeting, Parties (over 125 nations) to the Montreal Protocol amended the previous deadlines. The new deadlines on complete phase-out of use are 2015 and 2005 for developing and industrial nations, respectively.

### Federal Regulations

1. The U.S. EPA established tolerances in commodities based on inorganic bromide level because of the assumption that MB is degraded completely to bromide (Federal Register, 1991).

2. The oral reference dose (RfD) was determined to be 0.0014 mg/kg/day based on the no-observed-effect level (NOEL) of 1.4 mg/kg/day for forestomach epithelial hyperplasia in a rat oral subchronic study (Danse *et al.*, 1984) and an uncertainty factor of 1,000. The inhalation reference concentration (RfC) was $5 \times 10^{-3}$ mg/m$^3$ (1.3 ppb) based on the lowest-observed-adverse-effect level (LOAEL) of 3 ppm for nasal olfactory epithelial hyperplasia from a rat chronic inhalation study (Reuzel *et al.*, 1987 and 1991) and an uncertainty factor of 100.
3. The drinking water health advisories for MB for one-day, ten-day, and longer-term health advisory for a child is 0.1 mg/L assuming 1 L/day water consumption for a 10-kg child (U.S. EPA, 1992). The longer-term health advisory for an adult is 0.5 mg/L assuming 2 L/day water consumption for a 70-kg adult. The lifetime health advisory is 0.01 mg/L assuming 20% of exposure by drinking water.
4. MB is classified as a "Group D" carcinogen (not classifiable as to human carcinogenicity) by U.S. EPA due to inadequate human and animal data (U.S. EPA, 1992).

**California Regulations**

1. For occupational exposure to MB, the current permissible exposure limit (PEL) for MB is 5 ppm or 20 mg/m$^3$ and a ceiling limit of 50 ppm.
2. In 1992, monitoring data caused the DPR to be concerned regarding the risk from short-term exposures to MB both to structural workers and residents returning to recently fumigated structures. The DPR promulgated emergency regulations to decrease the exposure and required pest control operators to hand out a Fact Sheet explaining the potential human hazards of MB fumigation. Permit conditions were developed for soil, and commodity fumigation.
3. On January 1, 1993, MB, as structural fumigant, was administratively listed by the Office of Environmental Health Hazard Assessment (OEHHA) as a developmental toxicant under Proposition 65 via the provision for listing due to the federal label warning requirement.
4. The Proposition 65 Developmental and Reproductive Toxicity Identification (DART) Committee of the OEHHA Science Advisory Board decided that evidence from experimental animals had not "clearly shown" that MB caused developmental and reproductive toxicity. MB remains listed under Proposition 65 for structural fumigation uses only.

## FORMULATIONS

In 1998, more than 50 MB-containing products were registered in California. Table 1 shows % active ingredient (a.i.) and trade (product) names of 52 products. Some products contain chloropicrin as a warning agent. Chloropicrin is also a fumigant similar to MB in controlling pests. Detailed information on application rate and sites is available from the DPR home page. There is too much information to summarize or provide as hard copy in this document.

Table 1 presents a DPR database search of MB active products as of June 9, 1998.

Table 1. MB products registered in California in 1998.

| Product Name | Formulation | Company | % MB | % Chloropicrin listed as a.i. |
|---|---|---|---|---|
| 50-50 | P | A | 50 | 50 |
| 57-43 | P | A | 58 | 43 |
| 67-33 | P | G | 67 | 33 |
| 67-33 Preplant Soil Fumigant | P | A | 67 | 33 |
| 75-25 | P | A | 75 | 25 |
| 80-20 | PG | A | 79 | 19 |
| 98-2 | P | G | 98 | 0 |
| 98-2 Contains 2% Chloropicrin | P | A | 97.6 | 0 |
| Brom-76 | PG | S | 75 | 1 |
| Bromo-O-Gas (Liquid) | PG | G | 98 | 0 |
| Bromo-O-Gas 0.5% | PG | G | 99.5 | 0 |
| Bromo-O-Gas 0.25% | P | G | 99.75 | 0 |
| Bromo-O-Gas 2% | P | G | 98 | 0 |
| M-B-R 98 | P | AL | 98 | 0 |
| M-B-R 98 Technical | P | AL | 98 | 0 |
| Metabrom 100 | P | A | 99.7 | 0 |
| Metabrom 99 | P | A | 99.65 | 0.25 |
| Metabrom Q | PG | A | 100 | 0 |
| Meth-O-Gas | PG | G | 100 | 0 |
| Meth-O-Gas 100 | PG | G | 100 | 0 |
| Meth-O-Gas Q | P | G | 100 | 0 |
| Methyl Bromide | P | G | 100 | 0 |
| Methyl Bromide 100 | PG | S | 100 | 0 |
| Methyl Bromide 100 | PG | A | 100 | 0 |
| Methyl Bromide 89.5% | PG | T | 89.5 | 0 |
| Methyl Bromide 98% | P | S | 98 | 0 |
| Methyl Bromide 98% | PG | T | 98 | 0 |
| Methyl Bromide 99.5% | PG | S | 99.5 | 0 |
| Methyl Bromide 99.5% | PG | T | 99.5 | 0.5 |
| Methyl Bromide 99.75% | PG | S | 99.75 | 0 |
| Methyl Bromide Quarantine Fumigant | PG | S | 100 | 0 |
| Pic-Brom 25 | PG | S | 75 | 25 |
| Pic-Brom 33 | PG | S | 67 | 33 |
| Pic-Brom 43 | PG | S | 57 | 43 |
| Pic-Brom 50 | PG | S | 50 | 50 |
| Pic-Brom 55 | PG | S | 45 | 55 |
| Pic-Brom 67 | PG | S | 33 | 67 |
| Terr-O-Gas 57 | PG | G | 57 | 41.5 |
| Terr-O-Gas 67 | PG | G | 67 | 33 |
| Terr-O-Gas 75 | PG | G | 75 | 25 |
| Terr-O-Gas 80 | PG | G | 80 | 20 |
| Terr-O-Gas 98 | P | G | 98 | 2 |

Table 1 (cont.). MB products registered in California in 1998.

| Product Name | Formulation | Company | % MB | % Chloropicrin listed as a.i. |
|---|---|---|---|---|
| Tri-Brom | P | T | 99 | 0 |
| Tri-Con 45/55 | P | T | 45 | 55 |
| Tri-Con 50/50 | PG | T | 50 | 50 |
| Tri-Con 57/43 | PG | T | 57 | 42.6 |
| Tri-Con 67/33 | PG | T | 67 | 32.7 |
| Tri-Con 75/25 | PG | T | 75 | 24.8 |
| Tri-Con 80/20 | P | T | 80 | 19.8 |
| Tri-Con 80/20 | P | SM | 80 | 19.8 |
| Tri-Pan 76/24 | PG | T | 75 | 24.0 |
| TriCal Methyl Bromide 99.5% | P | SM | 99.5 | 0 |

P = pressurized liquid/sprays/foggers; PG = pressurized gas; A = Ameribrom, G = Great Lakes, S = Soil Chemical Corp; AL = Albermarle; T = TriCal; SM = Shadow Mountain (part of TriCal)

## USAGE

The use information from 1992 to 1995 provided by the Information Systems Branch, DPR, follows (Tables 2-5).

Table 2. Summary of usage in 1992 from the DPR database.

| | Usage | Lbs MB | % Total |
|---|---|---|---|
| A. | Soil (total) | 16,258,179 | 95.68 |
| | *Top five uses for soil*: | | |
| | Strawberry (All or Unspecified) | 4,963,112 | 29.21 |
| | Almond | 1,398,146 | 8.23 |
| | Preplant-Outdoor (Seedbeds, etc.) | 1,320,454 | 7.77 |
| | Sweet Potato | 1,250,084 | 7.36 |
| | Outdoor Container/Field Grown Plants | 1,001,320 | 5.89 |
| B. | Commodity -Post Harvest Fumigations (total) | 167,946 | 0.99 |
| | *Top five use for commodity*: | | |
| | Walnut (English Walnut, Persian Walnut) | 54,689 | 0.32 |
| | Fruits (Dried or Dehydrated) | 23,255 | 0.14 |
| | Grapes | 20,940 | 0.12 |
| | Cotton, General | 20,100 | 0.12 |
| | Storage Areas and Processing Equipment | 11,708 | 0.07 |
| C. | Structural Pest Control (total) | 566,771 | 3.34 |
| Grand Total (A + B +C) | | 16,992,896 | 100.00 |

Table 3. Summary of usage in 1993 from the DPR database.

| | Usage | Lbs MB | % Total |
|---|---|---|---|
| A. | Soil (total) | 12,276,186 | 95.29 |
| | *Top five uses for soil:* | | |
| | Strawberry (All or Unspecified) | 3,020,987 | 23.45 |
| | Soil Appl., preplant outdoor (seedbeds, etc.) | 1,206,515 | 9.37 |
| | Outdoor Container/Field Grown Plants | 1,075,246 | 8.35 |
| | Carrots, General | 811,955 | 6.30 |
| | Almonds | 739,713 | 5.74 |
| B | Commodity-Post Harvest Fumigations (total) | 154,898 | 1.20 |
| | *Top five uses for commodity*: | | |
| | Walnut (English Walnut, Persian Walnut) | 44,559 | 0.35 |
| | Grapes | 30,707 | 0.24 |
| | Prunes | 26,751 | 0.21 |
| | Figs | 18,064 | 0.14 |
| | Commercial, Institutional, or Industrial Areas | 7,194 | 0.06 |
| C. | Structural Pest Control (total) | 451,681 | 3.51 |
| Grand Total (A + B+ C | | 12,882,765 | 100.00 |

Table 4. Summary of usage in 1994 from the DPR database.

| | Usage | Lbs MB | % Total |
|---|---|---|---|
| A. | Soil (total) | 15,377,385 | 95.45 |
| | *Top five uses for soil*: | | |
| | Strawberry (All or Unspecified) | 4,749,484 | 29.48 |
| | Carrots (General) | 1,234,229 | 7.66 |
| | Grapes, Wine | 1,215,443 | 7.54 |
| | Preplant-Outdoor (Seedbeds, etc.) | 951,655 | 5.91 |
| | Outdoor Container/Field Grown Plants | 870,981 | 5.41 |
| B. | Commodity-Post Harvest Fumigations (total) | 203,096 | 1.26 |
| | Top five uses for commodity: | | |
| | Walnut (English Walnut, Persian Walnut) | 63,324 | 0.39 |
| | Fruits (Dried or Dehydrated) | 27,222 | 0.17 |
| | Grapes | 25,669 | 0.16 |
| | Beans, Dried-Type | 10,244 | 0.06 |
| | Regulatory Pest Control | 10,229 | 0.06 |
| C. | Structural Pest Control (total) | 529,252 | 3.29 |
| Grand Total (A + B + C) | | 16,109,733 | 100.00 |

Table 5. Summary of usage in 1995 from the DPR database.

| | Usage | Lbs MB | % Total |
|---|---|---|---|
| A. | Soil (total) | 16,409,415 | 95.59 |
| | *Top five uses for soil:* | | |
| | Strawberry (All or Unspec) | 4,807,068 | 28.00 |
| | Uncultivated Agricultural Areas (All or Unspec) | 1,351,162 | 7.87 |
| | Outdoor Container/Field Grown Plants | 1,118,650 | 6.52 |
| | Preplant-Outdoor (Seedbeds, etc.) | 1,050,123 | 6.12 |
| | Grapes, Wine | 1,014,388 | 5.91 |
| B. | Commodity-Post Harvest Fumigations (total) | 247,663 | 1.44 |
| | *Top five uses for commodity*: | | |
| | Walnut (English Walnut, Persian Walnut) | 93,783 | 0.55 |
| | Regulatory Pest Control | 24,080 | 0.14 |
| | Bushberries (bushfruits) | 19,303 | 0.11 |
| | Fruits (Dried or Dehydrated) | 17,594 | 0.10 |
| | Grapes | 14,382 | 0.08 |
| C. | Structural Pest Control (total) | 508,869 | 2.96 |
| Grand Total (A + B +C) | | 17,165,946 | 100.00 |

## LABEL PRECAUTIONS/PERSONAL PROTECTIVE EQUIPMENT

All MB products are classified as Toxicity Category I pesticides bearing a signal word "Danger/Poison." The general precautionary statements for MB read: *"Hazard to humans and domestic animals: Danger. Extremely hazardous liquid and vapor under pressure. Inhalation may be fatal or cause serious acute illness or delayed lung or nervous system injury. Do not breath vapors. Liquid or excessive vapor can cause serious skin or eye injury which may have a delayed onset. Do not get liquid on skin, in eyes, or on clothing.*" If the product contains chloropicrin, it further gives these statements: *"This product contains chloropicrin as a warning odorant. Chloropicrin may be irritating to the upper respiratory tract, and even lower levels can cause painful irritation to the eyes, producing tearing. If these symptoms occur, leave the fumigation area immediately*."

The labels also give the following restrictions: *Do not fumigate with MB when soil temperature is below approximately 50 $^{o}$F at 6 inches, do not wear jewelry, gloves, goggles, tight fitting clothing, rubber protective clothing, or rubber boots when handling. MB and chloropicrin are heavier than air and can be trapped inside clothing and cause skin injury.*

Product labels specify required personal protective clothing and equipment for workers. For example, applicators and other handlers must wear loose-fitting or well-ventilated long-sleeved shirt and long pants. The label requires respiratory protection when the air concentration level is above 5 ppm (20 mg/$m^3$) at any time. DPR has established the target 24-hour TWA of 210 ppb (Nelson, 1992). The respiratory protection must be one of the following types: 1) a supplied air-respirator (MSHA/NIOSH approval number prefix TC-19C) or 2) a self-contained breathing apparatus (SCBA) (MSHA/NIOSH approval number prefix TC-13F). Under normal soil fumigation conditions, the concentration of MB in the working area will not generally exceed 5 ppm and no respiratory protection is required. However, there is a possibility of a spill or leak during soil fumigation. Therefore, respiratory protection of a type specified above must be available and will be required for entry into the affected area in the event of a leak or spill.

## HUMAN ILLNESSES

MB can cause serious human illness, especially when health protection and regulations are lax. In the past, MB was used as a refrigerant and a basic chemical in fire extinguishers. Some published literature revealed a history of serious illnesses caused by these uses or by accidental exposure to MB. Watrous (1942) reported a case where 33 out of 90 workers experienced mild systemic symptoms. These workers were involved in a packaging process where they placed liquid MB in glass ampoules, sealed the ampoules and inspected them for leakage. The air concentration of MB in the work area was generally less than 35 ppm. Workers experienced symptoms of anorexia, nausea, vomiting, headache, vertigo, difficulty in focusing the eye, lethargy, muscular pains, and dimness of vision. Johnstone (1944) reported 34 known cases of MB intoxication that developed in the date-packing industry. An estimated 15 to 20 more packers were absent from work for a period of two to 10 days. The maximum allowable air concentration of MB at that time was 50 ppm. The high level of exposure was caused by leakage coupled with poor aeration after fumigation. The majority of workers had neurologic disturbances involving vision, speech, tremors, and numbness of the extremities. There was a high incidence of mental confusion and some hallucinations. Depressive states lasted as long as five months. Other published reports revealed symptoms of different severity and fatalities among workers and residents (von Oettingen, 1946; Mezel *et al*, 1948; MacDonald, *et al*., 1950; Ingram, 1951; Rathus and Randy, 1961; Longley and Jones, 1965; Alexeeff and Kilgore, 1983). Even though current California laws and regulations regarding the use of MB are more stringent than those in the 1940's and 1950's, illnesses still occur as a result of exposure to MB from various uses.

The Pesticide Illness Surveillance Program (PISP) of DPR maintains credible records of illnesses caused by MB. In California, physicians are required to report any illness or injury they suspect of being related to pesticide exposure. Data in Table 6 shows illnesses associated with exposure to MB and MB in combination with other pesticides from 1991 to 1995 (Mehler, 1997).

Table 6. Occupational and non-occupational illnesses associated with exposure to MB and MB in combination with other pesticide in California (1991-1995).

| MB alone | Illness/injury type | | | | Total | | |
|---|---|---|---|---|---|---|---|
| Activity | Systemic | Eye | Skin | Eye/skin | Def | Prob | Pos |
| 1. Occupational (occup.) | | | | | | | |
| Fumigation, field | 0 | 0 | 9 | 1 | 8 | 1 | 1 |
| Fumigation, tarpaulin | 3 | 0 | 0 | 0 | 0 | 1 | 2 |
| Fumigation, chamber | 8 | 0 | 0 | 0 | 2 | 4 | 2 |
| Exposed to drift | 12 | 0 | 0 | 0 | 2 | 0 | 10 |
| Residue and other | 4 | 0 | 1 | 0 | 2 | 0 | 3 |
| Emergency response | 8 | 0 | 0 | 0 | 2 | 3 | 3 |
| Exposed to concentrate | 2 | 0 | 0 | 0 | 0 | 2 | 0 |
| Total occupational | 37 | 0 | 10 | 1 | 16 | 11 | 21 |
| 2. Non-occupational | | | | | | | |
| Exposed to residues | 14 | 3 | 0 | 0 | 1 | 15 | 1 |
| Other | 3 | 0 | 0 | 0 | 3 | 0 | 0 |
| Total non-occupational | 17 | 3 | 0 | 0 | 4 | 15 | 1 |
| Occup. + non-occup. | 54 | 3 | 10 | 1 | 20 | 26 | 22 |
| Yearly average | 10.8 | 0.6 | 2 | 0.2 | 4 | 5.2 | 4.4 |

| MB in combination with other pesticides | Illness/injury type | | | | Total | | |
|---|---|---|---|---|---|---|---|
| Activity | Systemic | Eye | Skin | Eye/skin | Def | Prob | Pos |
| 1. Occupational | | | | | | | |
| Fumigation, field | 11 | 2 | 2 | 1 | 7 | 5 | 4 |
| Fumigation, drift | 7 | 1 | 0 | 0 | 1 | 5 | 2 |
| Other residues | 22 | 1 | 1 | 0 | 0 | 1 | 23 |
| Emergency response | 1 | 3 | 1 | 0 | 0 | 4 | 1 |
| Total occupational | 41 | 7 | 4 | 1 | 8 | 15 | 30 |
| 2. Non-occupational | | | | | | | |
| Exposed to drift or residue | 27 | 3 | 0 | 0 | 0 | 22 | 8 |
| Total non-occupational | 27 | 3 | 0 | 0 | 0 | 22 | 8 |
| Occup. + non-occup. | 68 | 10 | 4 | 1 | 8 | 37 | 38 |
| Yearly average | 13.6 | 2.0 | 0.8 | 0.2 | 1.6 | 7.4 | 7.6 |

Def = definite; Prob = probable; Pos = possible.

The 5-year average illnesses associated with exposure to MB alone and MB in combination with other pesticides are 13.6 and 16.6 cases per year, respectively (Table 6). The overall average is 30.2 cases per year. This average includes cases classified as "possible," accounting for about 40% of the overall average. The "possible" classification indicates some correspondence between the MB exposure described and the illness/injury experienced; whereas, the "definite"

classification indicates the signs and symptoms exhibited by the affected person are such as would be expected to result from the exposure described. The "probable" classification indicates there is close correspondence between the pattern of exposure and the illness or injury experienced.

Affected people described a variety of illness/injury symptoms associated with exposure to MB alone or MB in combination with chloropicrin. Table 7 shows symptoms reported by affected people in California from 1986 to 1995 for "definite" relationship category.

Table 7. Symptoms described by patients exposed to MB alone and in combination with chloropicrin in California (1986-1995).

| Illness/injury type | Observed symptoms* |
|---|---|
| Systemic/respiratory | Dizziness, lightheadedness, coughing, choking, nausea, headache, fever, shaking, sore throat, shortness of breath, vomiting, slurred speech, chest tightness and burning, disorientation, numbness on the cheek |
| Eye | Burning, irritation, tearing, double vision, itching, mild conjunctival inflammation, photophobia, moderate conjunctival irritation |
| Skin | Burning, pain, chemical burn, first and second degree burn, itching, painful swelling, redness, pruritic rash, blisters |

* symptoms are not arranged according to the degree of severity

**Evacuations after the use of MB**

From 1982 to 1995, there were four evacuations of people after the use of MB and chloropicrin (Mehler, 1997; Richmond, 1997). Summary of evacuations are as follows:

1. An evacuation occurred after a field was treated with MB and chloropicrin. The investigative report indicated that the apparent cause for the concentration of fumigants over the evacuation area was the lack of wind and a temperature inversion during and after the application, causing poor wind dilution and dispersion. As a result, 35 people were seen at local hospitals during evacuation. Systemic symptoms were experienced by these people.
2. Seventy-one people at a labor camp were evacuated after a nearby nine-acre field was tarp fumigated. These people detected fumes and exhibited symptoms of exposure (tearing burning eyes). This incidence was caused by the gas leak. The seriousness of the gas leak involved two main factors, which were vandalism and poor wind movement.
3. Twenty-five people were evacuated from an area after four cylinders of MB fell off the pallet. One of the cylinders leaked gas. An employee was exposed and became lightheaded. Only this employee developed illness symptoms.
4. Approximately 100 people were evacuated from apartments when an adjacent apartment complex, which had been tarped and fumigated with MB, emitted white smoke from a vent pipe. It was found out later that the source of the smoke was the water heater closet in the back of the building. The Hazardous Materials Team later declared the building was free of toxic gases. There were no illness/injury from this incidence.

From the same period (1982-1995), PISP received 24 reports involving people (generally seeking shelter) who entered enclosed areas treated with MB. The atmosphere in these areas contained a lethal level of MB. Eighteen of the 24 people died.

## DERMAL TOXICITY/SENSITIZATION

Symptoms observed in illness incidents indicate that liquid MB can cause severe eye and skin burns. The DPR's database does not have any submitted reports on dermal sensitization studies. Given the acute dermal toxicity of MB liquid, a sensitization study is not feasible.

## ANIMAL METABOLISM

1. Excretion routes and rates

In rats after inhalation exposure, excretion occurred in exhaled air (about 50% of absorbed dose), urine (20%) and feces (1%) (Medinsky *et al*., 1985). Urinary half-life was 9.9 hours. Excretion in the exhaled air was biphasic with a half-life of 4.1 hours in the initial phase and 17 hours in the second phase (Medinsky *et al*., 1985). Other studies have shown similar results (Bond *et al.*, 1985, Jackot *et al.*, 1988). In dogs, only 5.7 and 0.7% of the inhaled dose were found in the urine and feces, respectively (Raabe, 1986).

In rats after oral exposure, 46% of the absorbed dose was found in the bile, 12% in the exhaled air, and 7% in the urine (Medinsky *et al.*, 1984). In rats after intraperitoneal administration, 65% of the dose was found in the exhaled air, 16% in the urine, and 1 % in the feces (Medinsky *et al.*, 1984).

2. Estimate of oral bioavailability

The percentages of dose absorbed are: About 50% for inhalation in rats (Medinsky *et al.*, 1985), 40% for inhalation in dogs (Raabe, 1986), 55% for inhalation in humans (Raabe, 1988), >90% for oral gavage in rats (Medinsky *et al.*, 1984), and >90% for intraperitoneal administration in rats (Medinsky *et al.*, 1984).

## INHALATION UPTAKE/DERMAL ABSORPTION

**Inhalation uptake**

Inhalation uptake of MB was determined in beagle dogs (Raabe, 1986), in humans (Raabe, 1988), and in rats (Medinsky, 1985). Inhalation uptake of MB in adult nose-breathing beagle dogs was determined to be 39.8 percent (Raabe, 1986). In humans, the results were obtained from two males and two females in which uptake was evaluated by inhaling MB through mouth or nose. Means of the corrected inhalation uptake (observed uptake fraction x dead space

correction factor) when breathing by mouth and nose are 52.1 and 55.4 percent, respectively (Raabe, 1988). Inhalation uptake of MB (1.6-10 ppm) in rats was determined to be about 48 percent which is similar to inhalation uptake in beagle dogs and humans (Medinsky, 1985). Whenever it is necessary to estimate an absorbed dose from inhalation exposure, an inhalation absorption of 50% will be used. However, exposure estimates for MB in this document are shown as air concentrations instead of absorbed doses.

**Dermal absorption**

The DPR library database showed an article titled "Absorption of MB through the intact skin (Jordi, 1953)." Upon reviewing this article, there was no actual dermal absorption study of MB as indicated by the title of the article. This article reported the incidence of one fatal and two non-fatal cases of poisoning, which occurred after the fumigation of a flour mill. Results of the investigation revealed that the workers wore oxygen-supplying apparatus and there was enough oxygen during the fumigation period. All workers experienced illness symptoms at least one hour after the fumigation, which took one hour and 30 minutes.

On March 26, 1985, Great Lakes Chemical Corporation submitted a request to the U.S. EPA for a waiver of dermal exposure data (TriCal, 1987). The registrant provided several reasons with the request. However, the U.S. EPA did not grant a waiver because the registrant provided insufficient evidence to the Agency for consideration. The registrant resubmitted a request after a meeting with the U.S. EPA personnel about the type of a closed system for MB application. The registrant claimed that workers would not be exposed to liquid MB under normal usage. Additionally, the only possible dermal exposure would come from a spill situation and under these conditions the inhalation route would still be the most important means of exposure (TriCal, 1987). Hence, a dermal absorption study is not needed for MB. On February 24, 1986, the agency granted the waiver of dermal exposure data based upon reasons that MB is applied in a closed system and the volatile nature of MB (boiling point = 4 $^{o}$C). However, some questions still exist because there is a possibility that dermal absorption of MB is increased in areas with partly lipophilic character, such as armpit, groin, genitals, and the skin under the waist belt. This suggestion was substantiated by observations that skin lesions were limited to those areas where perspiration is relatively high (Zwaveling *et al*., 1987). However, these effects are only observed with extremely high ambient MB concentrations.

Dermal exposure may be important for those exposure scenarios in which dermal contact is the primary source of exposure, such as for workers who wear respirators in areas with relatively high concentrations of MB. Based upon illness reports in the literature, there is the potential for significant dermal exposure of workers who wear self-contained-breathing apparatus (SCBA) in high MB concentration environment and work in the area for extended periods. Zwaveling et al. (1987) and Hezemans-Boer (1988) reported skin lesions in six workers eight hours after exposure for 40 minutes to high concentration of MB of approximately 40 g/m$^3$ or 10,000 ppm during the fumigation of an enclosed building. These workers wore coveralls on top of normal daily clothing, PVC gloves, and work shoes. During the actual fumigation, these workers breathed pressurized air from a portable container through a tight fitting facemask. The skin lesions consisted of sharply demarcated erythema with multiple vesicles and large bullae. The lesions were limited to parts of the skin that were relatively moist and/or subjected to mechanical

stress such as the armpits, the groin, the labia, the vulva, the penis, the scrotum, the rima ani, the navel, and the skin under the waistbelt. The mean plasma bromide concentration for samples collected immediately after the exposure and 12 hours after the exposure were 95 ± 15 and 72 ± 24 μmol/L, respectively. It is possible that MB absorption is increased in this partly lipophilic (sebaceous glands) and partly hydrophilic (sweat glands) environment (Zwaveling et al., 1987). The percentage of dermal absorption could not be determined. Healing of the skin lesions of these workers occurred in 2 weeks. Deschamps and Turpin (1996) reported illnesses of two experienced fumigators who wore a cartridge respirator with activated charcoal. They entered a building where the concentration of MB was 17g/$m^3$. Under the very high MB concentration environment, it is likely that the respirator was rapidly saturated with MB. It is for this reason that NIOSH does not recommend any air-purifying respirator for MB.

Dermal absorption of vapors of chemicals other than MB was studied. Four human volunteers (naked excepted shorts) were exposed to styrene vapors in the air within the concentration range of 1,300 to 3,200 mg/$m^3$ for 2 hours (Wieczorek, 1985). These volunteers (3 men and 1 woman aged 25-35) breathed pure air from outside through a respirator. The results showed that dermal absorption of the styrene vapors contributed about 5% to the amount absorbed in the respiratory tract under the same conditions when the subjects did not wear a respirator. Riihimaki and Pfaffli (1978) studied percutaneous absorption of xylene, styrene, toluene, 1,1,1-trichloroethane, and tetrachloroethane vapors employing restricted numbers of human volunteers (n = 2-3 for each kind of vapor). The percutaneous absorption when the volunteers were exposed to moderate air concentrations of 300 and 600 ppm for 3.5 hours were about 0.1 to 2% of the amount estimated to be absorbed from the unprotected respiratory tract.

McDougal *et al.* (1985) studied dermal absorption of dibromomethane (DBM, 500 to 10,000 ppm) and bromochloromethane (BCM, 2,500 to 40,000 ppm) vapors in rats. The percentage of body burden, which was due to penetration of the skin, would be 5.8% for DBM and 4.2% for BCM. The observed permeability constants in rats for styrene, xylene, toluene, perchloroethylene, benzene, halothane, hexane, and isoflurane were estimated to be two to four times greater than the human permeability constants calculated from the available literature data (McDougal *et al,* 1990). Based upon the difference in absorption of various chemical vapors in rats and humans, the percentage of body burden in humans was assumed to be 1.5 to 2.9% for DBM and 1.1 to 2.1% for BCM.

In conclusion, the dermal absorption of MB can be significant based upon reported illnesses of individuals with SCBA exposed to high concentration of MB for extended periods. Dermal exposures of other gases in humans such as styrene, xylene, styrene, toluene, 1,1,1-trichloroethane, tetrachloroethane, dibromomethane, and bromochloromethane can be in the range of 0.1-5% of the unprotected respiratory exposure. However, there is no chemical-specific dermal absorption study for MB; we cannot meaningfully estimate dermal exposure at this time.

## FARM COMMODITY RESIDUES

MB is used to fumigate fresh fruits, vegetables, and raw agricultural and processed food commodities. These treatments are needed to control pests and to comply with U.S. import requirements and quarantines of other nations. Applications are usually made to fresh produce before it is loaded for export or to harvested crops before they are processed further. If the raw or processed commodity is stored for an extended period of time, additional fumigations may be necessary to control infestations of Indian meal moth and other pests. MB applications are made by treating the whole structure containing the commodity, covering the commodity with tarps or placing the commodity in a fumigation chamber. The treatment is a function of the application rate of the gas (pounds (Lbs) of MB per 1,000 $ft^3$ of commodity or space being treated), temperature of the commodity, exposure time and the load factor (percentage of the chamber area filled by the commodity). After the exposure period has expired, the commodity is aerated to remove the gas. Aeration can be a passive where the chamber doors are left open or the tarps are removed to allow the gas to dissipate. It can involve active ventilation where fans are used to exhaust the gas from chambers or to blow through the treated commodity.

The data in the Table 8 were derived from studies concerning the fumigation of various commodities. MB residues were detected in treated commodities using the headspace analytical method (King *et al.,* 1981) with the exception of treated wheat which was analyzed using the derivative method (Fairall *et al.,* 1980), the reflux method (Malone, 1970) and FDA methodology (CDFA, 1984b). Half-lives were calculated for the rates of dissipation of the organic bromide residues remaining after each treatment. These values were derived from the linear regression analysis of the time versus residue data points presented in the studies. The natural log of 2 was divided by the rate constant (slope) to estimate the half-life from the start of aeration.

Table 8 shows commodities that are representative of general fumigations. This table also contains information indicating how physical conditions and aeration can affect the amount of organic bromide residues left in the treated commodity. The temperature at which the commodity was treated and subsequently aerated and stored was the primary factor in determining the rate of dissipation of MB residues left in the treated commodity. As demonstrated in the residue data for "cherries," the greater the temperature, the more rapid the dissipation rate as expressed in the shorter half-life. Commodities fumigated at lower temperatures had greater amounts of organic bromide residues at the start of aeration than those treated at the same rate, but at a higher temperature (example; "cherries" and "pistachio meats"). As expected, the amount of organic bromide residues remaining after a treatment was directly proportional to the amount of fumigant used and the exposure period as shown in the "avocado" and "pistachio meats" data.

Certain commodities hold residual MB longer than others due to the lipophilic nature of organic halides. As a consequence, MB gas will dissipate slower from raw nuts than fresh fruits. In the fumigation study of fresh cherries (Sell *et al.*, 1987), it was observed in the laboratory that the desorption rate was independent of the ventilation rates tested.

The majority of the studies were conducted in the laboratory with fumigation chambers ranging in size from 1-28 $ft^3$, with almonds and walnuts fumigated in larger chambers (100-110 $ft^3$). Only the strawberry and wheat studies involved sampling for MB residues under actual commercial usage. Studies were conducted to test the hypothesis that chambers of various sizes might produce different dissipation rates. There may be some reservations regarding the use of this data to estimate commercial use conditions. MB fumigation studies were conducted comparing commercial and laboratory treatments of commodities at the same rates. The concentrations of MB were monitored in chambers of various sizes (0.028-5,494 $m^3$) during an inshell almond fumigation study (Hartsell *et al*., 1992). The levels of fumigant from an application of 24 $g/m^3$ at 26 $^oC$ for four hours were similar at various times: 28.3 L (0.028 $m^3$) chamber, 14.8-15.1 $g/m^3$ at 1.0 hour, 13.1-13.5 $g/m^3$ at 4 hours and the 5,494 $m^3$ chamber, 16.8 $g/m^3$ at 1.0 hour, 12.5 $g/m^3$ at 4 hours. A similar study was conducted during the fumigation and subsequent aeration of raisins (Hartsell *et al*., 1992). The regression analysis of the data points derived comparable rate constants (slopes) for the dissipation rates for up to eight days for the lab and commercial chambers.

A 1975 study of tarp fumigations with in hull almonds in piles at the harvest site observed the temperature variability that occurs when commodities are fumigated outdoors (Nelson *et al*., 1975). During the 24-hour fumigations, temperatures ranged from 69-79 $^oF$ at the bottom of the pile near the edge to 83-120 $^oF$ for one of the top corners at a depth of 1-2 feet. This temperature variability that occurs when commodities are tarp fumigated outdoors makes it difficult to predict the dissipation rate for the organic bromide residues.

Some studies investigated the effect of the commodity container on the dissipation rate of the MB. The almond fumigation study (Hartsell *et al*., 1984b) researchers observed that wooden bins with slots cut in the sides allowed the MB gas to dissipate faster than bins with solid sides. Harris *et al*. (1983) found that polystyrene foam boxes desorbed larger quantities of MB gas compared to cartons constructed of wood or fiberboard. When a fumigation chamber (49.6 $ft^3$) containing empty polystyrene foam grape boxes was fumigated, aerated and resealed, MB levels reached a maximum of 3.0 $g/m^3$. Sinclair and Lindgen (1952) noted that during the fumigation of empty flats for packing avocados, the excelsior packing material absorbed 20% of the applied MB in the chamber.

Table 8. A log-linear regression analysis of residue data over time from MB chamber fumigation of various commodities.

| Crop | Fumigation method | | | | Storage temp. (°C) | Rate constant[b] | Residues at aeration[c] (ppm) | $t_{1/2}$[d] (hours) |
|---|---|---|---|---|---|---|---|---|
| | Rate[a] | Time (hr) | Temp. (°C) | % Load | | | | |
| In shell almonds (shells) | 1 | 12 | 10 | 70-75 | n/a | -0.054 | 46.7 | 12.8 |
| In shell almonds (shells) | 1 | 8 | 15.6 | 70-75 | n/a | -0.051 | 17.3 | 13.6 |
| In shell almonds (shells) | 1 | 4 | 26.7 | 70-75 | n/a | -0.044 | 15.5 | 15.7 |
| In shell almonds (meats) | 1 | 12 | 10 | 70-75 | n/a | -0.018 | 9.5 | 38.4 |
| In shell almonds (meats) | 1 | 8 | 15.6 | 70-75 | n/a | -0.027 | 4.4 | 26.4 |
| In shell almonds (meats) | 1 | 4 | 26.7 | 70-75 | n/a | -0.023* | 4.9 | 31.2 |
| Almond meats in cartons | 1 | 8 | 15.6 | 70-75 | n/a | -0.047 | 13.4 | 14.8 |
| In shell walnuts (meats)[e] | 3.5 | 4 | 15.6 | 50-55 | 1.7 | -0.127 | 56.5 | 132 |
| In shell walnuts (meats)[e] | 3.5 | 4 | 15.6 | 50-55 | 10 | -0.162 | 50.2 | 103.2 |
| In shell walnuts (meats)[e] | 3.5 | 4 | 15.6 | 50-55 | 32 | -0.563 | 31.0 | 28.8 |
| Fresh strawberries[f] | 3 | 3 | 18.3 | n/r | n/a | -1.149 | 26.4 | 0.60 |
| Fresh strawberries[g] | 3 | 3 | 18.3 | n/r | 1.1 | -0.037* | n/a | 18.7 |
| Lemons | 2.75 | 2 | 21 | 50 | 10 | -0.021 | 2.2 | 33 |
| Grapefruit | 4 | 2 | 20 | 80 | 24 | -0.085 | 26.8 | 8.2 |
| Wheat in storage | 1.5 | 24 | 21 | 100 | 21 | -0.035* | 0.111 | 19.8 |
| Wheat in storage | 1.5 | 24 | 21 | 100 | 21 | -0.049* | 0.519 | 14.2 |
| Wheat in storage | 1.5 | 24 | 21 | 100 | 21 | -0.087* | 0.648 | 8.0 |
| Wheat in storage | 1.5 | 24 | 21 | 100 | 21 | -0.061 | 1.149 | 11.3 |
| Avocados (hass) whole fruit | 2 | 2 | 20 | 40 | 22 | -0.108* | 3.0 | 6.4 |
| Avocados (hass) whole fruit | 2 | 4 | 20 | 40 | 22 | -0.112* | 4.4 | 6.2 |
| Cherries | 3 | 2 | 3 | 32 | 3 | -0.296 | 83.5 | 2.3 |
| Cherries | 3 | 2 | 9 | 32 | 9 | -0.398 | 76.0 | 1.7 |
| Cherries | 3 | 2 | 23 | 32 | 23 | -0.636 | 59.2 | 1.1 |
| In shell pistachio meats[h] | 1 | 24 | 15.5 | 80 | 15.5 | -0.016 | 12.5 | 62.5 |
| In shell pistachio meats[h] | 1.5 | 24 | 15.5 | 80 | 15.5 | -0.014 | 20.6 | 49.5 |
| In shell pistachio meats[h] | 1.5 | 24 | 26.6 | 80 | 26.6 | -0.013 | 10.6 | 53.3 |
| In shell pistachio meats[h] | 3.5 | 24 | 26.6 | 80 | 26.6 | -0.014 | 20.1 | 49.5 |
| Peaches | 3 | 3 | 21 | 50-60 | 2.5 | -0.168* | 15.4 | 4.1 |
| Plums | 3 | 3 | 21 | 50-60 | 2.5 | -0.045 | 34.1 | 15.4 |
| Pears | 3 | 3 | 21 | 50-60 | 2.5 | -0.047 | 22.7 | 14.8 |
| Raisins | 1.5 | 24 | 10 | 50 | 10 | -0.005 | 1.3 | 139 |
| Dried apricots in bulk | 1.5 | 24 | 10 | 50 | 10 | -0.023 | 4.1 | 30.1 |
| Dried apricots in packages | 1.5 | 24 | 10 | 50 | 10 | -0.011 | 7.3 | 63 |
| Nonpitted prunes in bulk | 1.5 | 24 | 10 | 46 | 10 | -0.018 | 4.8 | 38.5 |
| Pitted prunes in bulk | 1.5 | 24 | 10 | 46 | 10 | -0.018* | 4.9 | 38.5 |
| Brown rice in 2 lb boxes | 1.5 | 16 | 21 | not known | 21 | -0.046* | 143.0 | 15.0 |
| Milled rice in 2 lb boxes | 1.5 | 16 | 21 | not known | 21 | -0.064* | 1.9 | 10.8 |

n/a-not applicable or no data available; n/r-not reported

Table 8 (cont.). A log-linear regression analysis of residue data over time from MB chamber fumigation of various commodities.

* the regression performed for this crop was found to be insignificant (with P-value >0.05).
[a] pounds MB per 1,000 $ft^3$.
[b] same as the regression coefficient (slope of the regression line) for natural log of MB concentration as a function of time.
[c] estimated residues at start of aeration. Residues were calculated based on y-intercept of the regression line.
[d] half-life ($t_{1/2}$) = log2/rate constant.
[e] fumigated at reduced pressure of 100 mm Hg.
[f] calculated as the mean from two replications.
[g] calculated with 1.0 ppb as 50% of the minimum detectable level.
[h] mean value of residues after three sequential treatments made at the listed rate, 20 days apart.

The following list cites the authors of the studies for each of the commodities listed in the Table 9.

1. almonds-Hartsell *et al*., 1984b.
2. pistachios-Hartsell *et al*., 1986.
3. walnuts-Hartsell *et al*., 1984a.
4. avocados-Singh *et al*., 1982.
5. cherries-Sell *et al*., 1987.
6. grapefruit-King *et al*., 1981.
7. prunes-Obenauf, 1992.
8. peaches-Tebberts *et al*., 1983.
9. pears-Tebberts *et al*., 1983.
10. plums-Tebberts *et al*., 1983.
11. strawberries-CDFA, 1984a.
12. wheat-CDFA, 1984b.
13. lemons-Soderstrom *et al*., 1991.
14. apricots-Hartsell *et al.*,1992.
15. rice-Anonymous, 1992.
16. raisins-Hartsell *et al.*, 1992.

Several fumigation trials observed the MB residues remaining in commodities when two different percents of load (10% versus 50%) were used in the chamber for the same treatment (Hartsell *et al*., 1992). A t-test of the differences in residues from the two load factors indicated that the percent load may affect the amount of residues remaining in the fumigated commodity. However, the t-test may not be an appropriate method for determining if the difference is significant because the samples were not randomly taken.

The treatment conditions described in Table 8 for strawberries are typical for commercial treatments as indicated in a survey conducted by the Strawberry Advisory Board (Riggs, 1992). The almond study results in Table 9 are supported by research conducted by Hartsell *et al*. (1988) for the Almond Board of California.

Table 9. A log-linear regression of dissipation rates for MB residues and temperature by almond.

| Crop | Treatment method | Intercept | Slope of regression[a] | Coefficient of determination ($r^2$) |
|---|---|---|---|---|
| In shell almonds (shells)[b] | chamber | -5.058 | 691.43 | 0.996 |

[a] based on the Arrhenius equation log(rate constant) = a + b(1/K), where rate constant is taken from Table 8 and K is temperature in degree Kelvin.

[b] fumigated at reduced pressure of 100 mm Hg.

## EXPOSURE ASSESSMENT

MB exposure estimates include those for workers during fumigation of preplant soil, agricultural commodities, or structures as well as for residents who live in or near fumigated residences and residents who live at an established buffer zone of commodity fumigation. Air concentrations of MB at specified periods are shown as parts per billion (ppb) or parts per million (ppm) by volume whenever they are appropriate.

The exposure estimates are grouped into acute and non-acute exposures depending on the nature of each work task or exposure scenario. Acute exposure is the exposure that occurs daily or within 24 hours. Non-acute exposures, as used in this document, are those exposures that occur in these exposure periods: 7 days (subacute), 90 days (subchronic), and 365 days (chronic) (Sanders, 1998). Frequency and duration of exposure for each work task or exposure scenario are used to determine whether the exposure is an acute or non-acute. These exposure scenarios also reflect toxicological endpoints observed in experimental animals as determined by DPR.

Calculations of exposure rely on factors, including application rates, work periods specified in the current California permit conditions, frequency and duration of exposure. Types of tarpaulins, application equipment, and injection depth are used in the permit conditions to determine the maximum daily work time for each type of soil injection fumigation. DPR has requested registrants to provide frequency and duration of exposure for acute and non-acute exposures (Donahue, 1997). So far, registrants have provided some data as requested. Consequently, default frequency and duration of exposure for many exposure scenarios were generated from data obtained from various sources and the use of professional judgment (Haskell, 1998a, 1998b). These default values are shown in Appendix A.

As shown in the previous section on formulations, many methyl bromide products contain chloropicrin. However, exposure assessment of chloropicrin has not been initiated at this time. This chemical has been placed in a high priority list under the Birth Defect Prevention Act of 1984 (SB 950). The exposure assessment may be initiated depending on the priority of the Department's risk assessment.

**Exposure calculation procedures**

MB exposure estimates are calculated for acute and non-acute exposures for applicable exposure scenarios. In each case, the air concentration is shown as the 24-hour TWA. (*Notes:* Lbs a.i. as used in this document is equivalent to Lbs MB unless mentioned otherwise. Lbs formulated product may include only MB or MB and chloropicrin.)

a) Acute exposures

Procedures used to estimate the 24-hour TWA concentration are as follows:

a.1) Volume of air sample at standard temperature and pressure of 25 $^{o}$C and 760 mm Hg

$$VS = \frac{V \times P \times 298}{760 \times (T + 273)}$$

Where: VS = volume of air (L) at standard conditions
V = volume of air sample (L) as measured
P = measured barometric pressure in mm Hg
T = measured temperature of air in $^{o}$C

a.2) Calculation of MB concentrations (ppm) in air

$$MB\ (ppm) = \frac{\mu g \times 24.45}{VS \times 94.94} = \frac{\mu g \times 0.2576}{VS}$$

Where: One mole of MB occupies 24.45 liters at 25 $^{o}$C and the molecular weight is 94.94.

a.3) Conversion of MB from $\mu g/m^3$ to ppb and vice versa

$$1\ ppb = \frac{24.45}{94.94} \times \mu g/m^3 = 0.26\ \mu g/m^3$$

$$1\ \mu g/m^3 = \frac{94.94}{24.45} \times ppb = 3.88\ ppb$$

a.4) Calculation of the 24-hour TWA concentration

$$TWA = \frac{C_1T_1 + C_2T_2 + C_nT_n}{24\ hours}$$

Where: TWA = MB concentration (ppb, ppm, $\mu g/m^3$, or $mg/m^3$
C = concentration of MB during an increment of exposure
T = incremental exposure time

b) Non-acute exposures

The non-acute exposure estimates shown in this document represent subacute, subchronic, and chronic exposures. The underlying reason for non-acute exposure is that workers or residents may be exposed to airborne MB either continuously or intermittently for longer than 24 hours. The duration and frequency of exposures for non-acute exposures were used to estimate exposure. Exposure for the subacute or subchronic period is that period during the maximum or peak use of MB for any fumigation purposes. Basically, the non-acute exposure estimates are determined from daily exposures either as acute, subchronic, or chronic exposure as shown below.

$$\text{Non-acute exposure estimate (ppb)} = \frac{\text{Daily exposure (ppb)} \times \text{Days of exposure (days)}}{\text{Exposure period (7, 90 or 365 days)}}$$

Notes:

1. Daily acute, subchronic or chronic exposure is shown as the 24-hour TWA (Tables 13-34 and 37-38).
2. Days of exposure for subacute, subchronic or chronic exposure are shown in Appendix A and also in Table 11.
3. Default exposure periods for subactute, subchronic, and chronic are 7, 90, and 365 days, respectively.

**Definitions:**

The "**High Barrier**" tarpaulin must have a permeability factor of less than 8 milliliters MB per hour, per square meter, per 1,000 ppm of MB under tarp at 30 $^{o}$C. Any polyethylene tarp of 6-mil thickness or greater meets this criterion.

The "**Very High Barrier**" tarpaulin must have a permeability factor of less than 5 milliliters MB per hour, per square meter, per 1,000 ppm of MB under tarp at 30 $^{o}$C.

"n/a" means not applicable.

**Availability of worker exposure studies:**

Before 1992 studies were conducted using then-current soil injection equipment which often resulted in high air concentrations of MB near the worker's breathing zone. Subsequently, DPR required registrants to conduct many exposure studies in order to determine short-term air concentrations of MB in various uses and exposure scenarios. Starting in 1992, registrants of MB conducted exposure monitoring studies during the fumigation of preplant soil, agricultural commodities, and other structures. Submitted reports indicate that many studies were not conducted in compliance with Good Laboratory Practice (GLP) standards as indicated in 40 CFR 160 (U.S. EPA, 1998). The main reason why these studies were not in GLP compliance because there was no valid field or laboratory fortification recovery study.

a) Summary of MB exposure studies conducted before 1992

In 1987, TriCal, Inc. submitted reports of several worker exposure studies (TriCal, 1987). The first data set consisted of exposure data generated during fumigations of a flour mill, processing and handling silo, grain silo, shipping container, transportation vehicle (barge loaded with oak logs), furniture covered with tarpaulin, and flat storage fumigation (corn, soybeans). The studies

were conducted based on NIOSH method No. S372. Air samples were collected from the worker's breathing zone using a sampling train that consisted of two 600 mg coconut shell charcoal sampling tubes and a personal air sampling pump. The principle of quality control/quality assurance was observed during the studies. The analytical recovery for MB ranged from 95 to 117%. Results were reported as the 8-hour TWA (Table 10). The application rates for most uses were not noted, but the report indicated that label instructions were followed.

Table 10. Air concentrations of MB near the worker's breathing zone.

| Type of fumigation | Work task | n | 8-hr TWA (ppm) Average ± SD (range) |
|---|---|---|---|
| 1. Flour mill | | | |
| a) Applicators opened gas tanks located inside the building. | Applicators | 9 | 4.1 ± 4.4 (0.04-13) |
| | Aerators | 7 | 7.8 ± 6.9 (0.01-15) |
| | Tape removers | 1 | 0.4 |
| b) Applicators opened gas tanks located outside the building. | Applicators | 4 | 0.2 ± 0.27 (0.06-0.61) |
| | Aerators | 3 | 5.5 ± 7.3 (1.1-14) |
| 2. Processing and handling silo (enclosed conveyer and storage bins) | Applicators | 3 | 7.3 ± 5.0 (2.7-12.6) |
| | Aerators | 2 | 0.07 (0.03 and 0.1) |
| 3. Grain silo, elevator, or bin | Applicators | 3 | 0.5 ± 0.1 (0.4-0.6) |
| | Aerators | 3 | 0.2 (ND) |
| | Grain loaders | 2 | 0.2 (ND) |
| 4. Shipping containers (trailers or rail cars) | Applicator | 1 | 0.02 |
| | Aerator | 1 | 6.8 |
| 5. Transportation vehicle (barge loaded with oak logs) | Applicator | 3 | 0.6 ± 0.3 (0.05-0.9) |
| | Supervisor | 1 | 0.04 |
| | Inspectors | 1 | 0.02 |
| | Aerators | 2 | 16.1 (7.1 and 25) |
| | Tarp removers | 2 | 0.4 (0.3 and 0.5) |
| 6. Tarpaulin (wooden furniture and a pallet of flour) | Applicators | 2 | 0.1 |
| | Tarp remover | 1 | 0.2 |
| | Aerator | 1 | 1.3 |
| 7. Flat storage building (filled to the ceiling with corn, soybeans) | Applicator | 3 | 0.25 ± 0.1 (0.2-0.3) |
| | Helpers | 2 | 0.1 (0.02 and 0.2) |
| | Aerators | 2 | 0.1 (0.02 and 0.2) |

n = number of replicates. Minimum detectable level (MDL) ranged from 0.01 to 0.4 ppm depending on sample volume; one-half of the MDL was used whenever the result indicated "non-detects (ND)."

TriCal, Inc. also conducted worker exposure studies to determine exposures of tractor drivers and co-pilots to MB during tarpless bed fumigation (TriCal, 1990). Application rates ranged from 50 to 360 pounds MB per acre and the injection depth ranged from 4 to 18 inches under the soil surface. Air concentrations at various distances from treated fields were also measured. The application of MB in these studies presumably used unmodified application equipment, unlike those currently used to reduce worker exposure. Exposure ranges (ppm) for drivers obtained from

four studies were 0.009-1.500 (carrots), 2.952-4.772 (potatoes), 0.648-1.704 (seedbed), and 1-2.1 (broccoli), and those for co-pilots were 0.270-1.524 (carrots), and 2.544-3.212 (seedbed). These air concentrations are high compared to the current target exposure level of 210 ppb for acute toxicity. The downwind air concentrations, measured 60 to 200 feet from treated fields, ranged from 0.03-0.211 ppm.

TriCal, Inc. also submitted several other studies that measured MB air concentrations near the worker's breathing zone (TriCal, 1987). These studies are listed below:

1. Deep tarpless application, Wasco, California. April 2, 1986. DPN 123-099, record number 64750.
2. Deep tarpless application, Delano, California. May 30, 1986. DPN 123-099, record number 64750.
3. Tarped field fumigation, Ducor, California. April 2, 1984. DPN 123-099, record number 64750.
4. Driscoll chamber fumigation, Watsonville, California. March 26, 1984. DPN 123-099, record number 64750.
5. Driscoll chamber fumigation (strawberries for export), Watsonville, California. July 18, 1984. DPN 123-099, record number 64750.
6. A study of the inhalation exposure of workers to MB and chloropicrin during preplant soil fumigations (shallow injection) in 1982 - A preliminary report. DPN 123-099, record number 64751 (or HS-1076, June 10, 1983, DPR).
7. A study of the inhalation exposure of workers to MB during preplant soil fumigations (shallow injection) in 1980 and 1981. DPN 123-099, record number 64752 (or HS-900, May 20, 1982, DPR).
8. A study of the levels of MB and chloropicrin in the air downwind from a field during and after a preplant soil fumigation (shallow injection)-A preliminary report. DPN 123-099, record number 64753 (or HS-1061, April 15, 1983, DPR).

Results from these studies are not employed for estimation of worker exposure due to one or more reasons listed below.

1. The report does not contain adequate information concerning fumigation method, sample collection and processing, and analysis (QA/QC) to ensure correct calculation of the TWA air concentrations.
2. The study used unacceptable analytical method.
3. There are better studies conducted in and after 1992.
4. The older studies do not reflect current work practices.

b) Summary of MB exposure studies conducted in and after 1992

Exposure estimates from studies conducted in and after 1992 are summarized in Table 11. These exposure estimates are shown as acute, subacute, subchronic and chronic exposure. Details of the exposure studies are presented in Appendices B, C, and D. Factors concerning frequency and duration of exposure for various work tasks and exposure scenarios are shown in Appendix A.

Table 11. Acute and non-acute exposure estimates of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| 1. Shallow shank-tarped soil injection fumigation (T.13; 1.a) | | | | | | | | | | | | |
| Applicators: Noble plow shanks | 111 | 98 | 3-303 | 6 | 95 | 84 | 40 | 49 | 44 | n/a | n/a | n/a |
| 2. Shallow shank-tarped soil injection fumigation (T.14; 1.a) | | | | | | | | | | | | |
| Co-pilots: Noble plow shanks | 224 | 152 | 34-518 | 6 | 192 | 130 | 40 | 100 | 68 | n/a | n/a | n/a |
| 4. Shallow shank-tarped soil injection fumigation (T.15; 1.a) | | | | | | | | | | | | |
| Shovelmen: Noble plow shanks (by growers) | 147 | 135 | 52-515 | 3 | 63 | 58 | n/a | n/a | n/a | n/a | n/a | n/a |
| 5. Shallow shank-tarped soil injection fumigation | | | | | | | | | | | | |
| Tarp removers (by PCOs) (T.16; 1.a) | 835 | 596 | 3-1659 | 5 | 596 | 426 | 55 | 510 | 364 | n/a | n/a | n/a |
| Tarp removers (by growers) (T.17; 1.a) | 278 | 199 | 1-553 | 2 | 79 | 57 | n/a | n/a | n/a | n/a | n/a | n/a |
| 6.a Deep shank injection fumigation (T.18; 1.b) | | | | | | | | | | | | |
| Applicators | 154 | n/a | 126&181 | 6 | 132 | n/a | 40 | 68 | n/a | n/a | n/a | n/a |
| Co-pilots | 49 | n/a | n/a | 6 | 42 | n/a | 40 | 22 | n/a | n/a | n/a | n/a |
| Cultipacker | 99 | n/a | n/a | 6 | 85 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 6.b Improved deep shank injection fumigation (T.18; 1.b) | | | | | | | | | | | | |
| Applicator | 57 | n/a | n/a | 6 | 49 | n/a | 40 | 25 | n/a | n/a | n/a | n/a |
| Cultipacker | 70 | n/a | n/a | 6 | 60 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 7. Deep shank injection fumigation (T.19; 1.c) | | | | | | | | | | | | |
| Appl: Basic + a second tractor with a disc | 88 | n/a | n/a | 6 | 75 | n/a | 40 | 39 | n/a | n/a | n/a | n/a |
| Disc driver: Basic + a 2nd tractor with a disc | 512 | n/a | n/a | 6 | 439 | n/a | 40 | 228 | n/a | n/a | n/a | n/a |
| Applicator: Basic + a cultipacker | 94 | n/a | 22&165 | 6 | 81 | n/a | 40 | 42 | n/a | n/a | n/a | n/a |
| Supervisor: Basic + a cultipacker | 67 | n/a | n/a | 6 | 57 | n/a | 40 | 30 | n/a | n/a | n/a | n/a |
| Cultipack.: Basic + a cultipacker (by growers) | 34 | n/a | 10&58 | 6 | 29 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 8. Deep shank injection fumigation (T.20; 1.d) | | | | | | | | | | | | |
| Applicator: With 4 forward curved shanks | 7 | n/a | n/a | 6 | 6 | n/a | 40 | 3 | n/a | n/a | n/a | n/a |
| Cultipack: 4 forward curved shanks (grower) | 7 | n/a | n/a | 6 | 6 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

* subchronic and chronic exposure estimates were calculated based upon daily 24-hour TWA for subchronic and chronic exposures shown in tables 13-31 and 38. Only subacute exposure (Numbers 20, 22, and 23 corresponding to Tables 32, 34, and 37) were calculated from acute exposure. Acute exposures during aeration of fumigated houses (Number 21 or Table 33) was assumed. Duration and frequency of exposure are shown in Appendix A.

Notes: 1. A standard deviation (STDEV) was not calculated when there were only two exposure values; the exposure data are shown as "xx&xxx."
2. T. = Table; exp. = exposure; by growers or PCOs = employed by growers or PCOs; Avg. = average; conv. = conventional; inj. = injection; Tr. = tractor.

Table 11 (continued 1). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| 9. Shallow shank-tarped bed fumigation (T.21; 1.e) | | | | | | | | | | | | |
| Appl: Conv.+ raised platform and inj. 8" | 80 | n/a | n/a | 6 | 69 | n/a | 40 | 36 | n/a | n/a | n/a | n/a |
| Co-pilots: Conv.+ raised platform&inj. 8" | 104 | n/a | 98&111 | 6 | 89 | n/a | 40 | 46 | n/a | n/a | n/a | n/a |
| Applicators: Conv. + closing shoes | 44 | n/a | n/a | 6 | 38 | n/a | 40 | 20 | n/a | n/a | n/a | n/a |
| Co-pilots: Conv. + closing shoes | 167 | n/a | 125&209 | 6 | 143 | n/a | 40 | 74 | n/a | n/a | n/a | n/a |
| 10. Shallow shank tarped-bed fumigation (T.22; 1.f) | | | | | | | | | | | | |
| Driver: Tr. was equipped for fum. (by PCOs) | 28 | n/a | n/a | 6 | 24 | n/a | 40 | 12 | n/a | n/a | n/a | n/a |
| Appl: Tractor was equipped for MB fum. | 45 | n/a | n/a | 6 | 39 | n/a | 40 | 20 | n/a | n/a | n/a | n/a |
| Tape layer: Tr. was equipped for MB fum. | 65 | n/a | n/a | 3 | 28 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Driver: Tractor was equipped for laying tarp | 4 | n/a | n/a | 6 | 3 | n/a | 40 | 1.8 | n/a | n/a | n/a | n/a |
| Co-pilot: Tr was equipped for laying tarp | 34 | n/a | 4&65 | 6 | 29 | n/a | 40 | 15 | n/a | n/a | n/a | n/a |
| 11. Shallow shank, tarped-bed fumigation (T.23; 1.g) | | | | | | | | | | | | |
| Applicator | 3 | n/a | n/a | 6 | 3 | n/a | 40 | 1 | n/a | n/a | n/a | n/a |
| Co-pilot | 31 | n/a | 31&31 | 6 | 27 | n/a | 40 | 14 | n/a | n/a | n/a | n/a |
| Shovelman (by growers) | 0.6 | n/a | 0.6&0.6 | 3 | 0.3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Pipe layer (by growers) | 2 | 0 | 2-2 | 3 | 1 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Irrigation pipe tractor driver (by growers) | 411 | 477 | 1-918 | 3 | 176 | 204 | n/a | n/a | n/a | n/a | n/a | n/a |
| 12. Tarp shallow with Noble plow shanks (T.24; 1.h) | | | | | | | | | | | | |
| Cutter: From broadcast appl. (by growers) | 82 | 134 | 3-237 | 2 | 23 | 38 | n/a | n/a | n/a | n/a | n/a | n/a |
| Cutter: From broadcast appl. (by PCOs) | 82 | 134 | 3-237 | 5 | 59 | 96 | 30 | 27 | 45 | n/a | n/a | n/a |
| Puller: From broadcast appl. (by growers) | 33 | 92 | 3-324 | 2 | 9 | 26 | n/a | n/a | n/a | n/a | n/a | n/a |
| Puller: From broadcast appl. (by PCOs) | 33 | 92 | 3-324 | 5 | 24 | 66 | 30 | 11 | 31 | n/a | n/a | n/a |
| 13. Tarp shallow with Noble plow shanks (T.25; 1.i) From use of high barrier (HB) tarp | | | | | | | | | | | | |
| Cutter: By PCOs | 78 | n/a | n/a | 5 | 56 | n/a | 30 | 26 | n/a | n/a | n/a | n/a |
| Remover: Tractor driver (by PCOs) | 343 | n/a | n/a | 5 | 245 | n/a | 30 | 114 | n/a | n/a | n/a | n/a |
| Remover: Basketman (by PCOs) | 325 | n/a | n/a | 5 | 232 | n/a | 30 | 108 | n/a | n/a | n/a | n/a |
| Remover: End puller (by PCOs) | 7 | n/a | n/a | 5 | 5 | n/a | 30 | 2 | n/a | n/a | n/a | n/a |
| Cutter (by growers) | 78 | n/a | n/a | 5 | 56 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Remover: Tractor driver (by growers) | 343 | n/a | n/a | 5 | 245 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Remover: Basketman (by growers) | 325 | n/a | n/a | 5 | 232 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Remover: End puller (by growers) | 7 | n/a | n/a | 5 | 5 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

Table 11 (continued 2). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| 14. Nursery potting soil fumigation (T.26; 2.a) | | | | | | | | | | | | |
| Applicators | 21 | n/a | 17&26 | 1 | 3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Applicator assistants | 16 | n/a | 1&31 | 1 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Tarp removers | 94 | 38 | 43-133 | 1 | 13 | 5 | n/a | n/a | n/a | n/a | n/a | n/a |
| Tractor drivers | 16 | n/a | 1&31 | 1 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Truck drivers | 3 | 4 | 1-8 | 1 | 0.4 | 0.6 | n/a | n/a | n/a | n/a | n/a | n/a |
| Potters | 32 | 43 | 2-95 | 1 | 5 | 6 | n/a | n/a | n/a | n/a | n/a | n/a |
| 15. Greenhouse soil fumigation (T.27; 2.b) | | | | | | | | | | | | |
| Applicators | 562 | n/a | 401&724 | 1 | 80 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Tarp venters | 93 | 160 | 0.6-333 | 1 | 13 | 23 | n/a | n/a | n/a | n/a | n/a | n/a |
| Tarp removers | 1 | 1 | 0.2-2 | 1 | 0.1 | 0.1 | n/a | n/a | n/a | n/a | n/a | n/a |
| 16. Fumigation of grain products (chambers, vans, etc.) (T.28; 3) | | | | | | | | | | | | |
| Fumigation applicator | | | | | | | | | | | | |
| Applicator | 1652 | 1462 | 792-3340 | 5 | 1180 | 1044 | 45 | 895 | 792 | 180 | 679 | 601 |
| Initiation of aeration of sea containers/truck trailers | | | | | | | | | | | | |
| Aerator | 6039 | 4062 | 1349-8458 | 5 | 4314 | 2901 | 45 | 3271 | 2201 | 180 | 2482 | 1669 |
| Initiation of aeration of tarpaulin fumigation | | | | | | | | | | | | |
| Aerator | 251 | 411 | 14-726 | 5 | 179 | 294 | 45 | 136 | 223 | 180 | 103 | 169 |
| Emptying sea containers/truck trailers | | | | | | | | | | | | |
| Forklift driver | 16 | 24 | 2-43 | 5 | 11 | 17 | 45 | 4 | 6 | 180 | 4 | 6 |
| Emptying non-certifying fumigation chambers | | | | | | | | | | | | |
| Forklift driver | 6 | 2 | 4-8 | 5 | 4 | 1 | 45 | 2 | 1 | 180 | 1 | 0.5 |
| Air monitoring in fumigated rice warehouse | | | | | | | | | | | | |
| Ambient air | 32 | n/a | 10&55 | 5 | 23 | n/a | 45 | 16 | n/a | 180 | 16 | n/a |
| Reprocessing fumigated rice products | | | | | | | | | | | | |
| Workers | 10 | 0 | 10-10 | 5 | 7 | 0.0 | n/a | n/a | n/a | n/a | n/a | n/a |
| 17. Fumigation of dried fruit and tree nut products (T.29; 4) | | | | | | | | | | | | |
| a) Sea Van | | | | | | | | | | | | |
| Fumigator | 33 | n/a | n/a | 2 | 9 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Fumigator observer | 9 | n/a | n/a | 2 | 3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 15-ft downwind | 3 | n/a | 2&4 | 2 | 0.9 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| b) Chamber (dried prunes): | | | | | | | | | | | | |
| Forklift operator | 0.35 | n/a | n/a | 3 | 0.2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Fumigators | 938 | n/a | n/a | 3 | 402 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 1 meter from open door | 0.78 | n/a | n/a | 3 | 0.3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 2 m from chamber | 141 | n/a | n/a | 3 | 60 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 15 m from chamber | 5 | n/a | n/a | 3 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Leak check, side seal of chamber | 13281 | n/a | n/a | 3 | 5692 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

Table 11 (continued 3). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| c) Big chamber fumigation (raisins): | | | | | | | | | | | | |
| Primary fumigator | 800 | n/a | n/a | 5 | 571 | n/a | 60 | 445 | n/a | 170 | 311 | n/a |
| Secondary fumigator | 118 | n/a | n/a | 5 | 84 | n/a | 60 | 65 | n/a | 170 | 46 | n/a |
| Aerators | 490 | n/a | 55&925 | 5 | 350 | n/a | 60 | 272 | n/a | 170 | 190 | n/a |
| Forklift drivers | 49 | 19 | 31-69 | 5 | 35 | 14 | 60 | 26 | 10 | 170 | 18 | 7 |
| Catchall operator | 203 | n/a | n/a | 5 | 145 | n/a | 60 | 135 | n/a | 170 | 95 | n/a |
| Hopper operators | 160 | n/a | 93&227 | 5 | 114 | n/a | 60 | 107 | n/a | 170 | 75 | n/a |
| Capper dumper | 127 | n/a | n/a | 5 | 91 | n/a | 60 | 85 | n/a | 170 | 59 | n/a |
| Inspector | 15 | n/a | n/a | 5 | 11 | n/a | 60 | 10 | n/a | 170 | 7 | n/a |
| Moisture checker | 9 | n/a | n/a | 5 | 6 | n/a | 60 | 6 | n/a | 170 | 4 | n/a |
| Forklift to side hopper | 8 | n/a | n/a | 5 | 6 | n/a | 60 | 4 | n/a | 170 | 3 | n/a |
| Stem pickers | 22 | 6 | 16-28 | 5 | 16 | 4 | 60 | 15 | 4 | 170 | 10 | 3 |
| Packer 1 | 19 | n/a | n/a | 5 | 14 | n/a | 60 | 13 | n/a | 170 | 9 | n/a |
| | | | | | | | | | | | | |
| Area samples: | | | | | | | | | | | | |
| Shed-Green forklift | 117 | n/a | n/a | 5 | 84 | n/a | 60 | 62 | n/a | 170 | 43 | n/a |
| Shed-Blue tractor | 173 | n/a | n/a | 5 | 124 | n/a | 60 | 92 | n/a | 170 | 64 | n/a |
| Aeration-sheds 604-606 | 1292 | 780 | 700-2175 | 5 | 923 | 557 | 60 | 717 | 433 | 170 | 501 | 303 |
| Capper area | 280 | n/a | n/a | 5 | 200 | n/a | 60 | 187 | n/a | 170 | 130 | n/a |
| Hopper area #2 | 61 | n/a | n/a | 5 | 44 | n/a | 60 | 41 | n/a | 170 | 28 | n/a |
| Catchoff area | 127 | n/a | n/a | 5 | 91 | n/a | 60 | 85 | n/a | 170 | 59 | n/a |
| Side hopper area | 23 | n/a | n/a | 5 | 16 | n/a | 60 | 15 | n/a | 170 | 11 | n/a |
| Stem picker area-A | 10 | n/a | n/a | 5 | 7 | n/a | 60 | 7 | n/a | 170 | 5 | n/a |
| Filer area, E-line | 19 | n/a | n/a | 5 | 14 | n/a | 60 | 13 | n/a | 170 | 9 | n/a |
| | | | | | | | | | | | | |
| d) Chamber (raisins): | | | | | | | | | | | | |
| Fumigators | 63 | n/a | 19&107 | 6 | 54 | n/a | 63 | 44 | n/a | 150 | 17 | n/a |
| Aerators | 47 | n/a | 30&64 | 6 | 40 | n/a | 63 | 33 | n/a | 150 | 13 | n/a |
| Clear chambers 1-2 | 1434 | n/a | 1406&1463 | 6 | 1229 | n/a | 63 | 1004 | n/a | 150 | 393 | n/a |
| Stem pickers | 28 | n/a | 26&30 | 6 | 24 | n/a | 63 | 20 | n/a | 150 | 12 | n/a |
| Forklift driver | 3 | n/a | n/a | 6 | 3 | n/a | 63 | 2 | n/a | 150 | 0.4 | n/a |
| Hopper operator | 19 | n/a | n/a | 6 | 16 | n/a | 63 | 13 | n/a | 150 | 8 | n/a |

Table 11 (continued 4). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| Area sampling: | | | | | | | | | | | | |
| Fumigation chambers | 88 | n/a | n/a | 6 | 75 | n/a | 63 | 62 | n/a | 150 | 24 | n/a |
| Fumigation cage | 54 | n/a | n/a | 6 | 46 | n/a | 63 | 38 | n/a | 150 | 15 | n/a |
| Leak checkers-chambers 4-5 | 4 | n/a | 2&6 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Aeration-chambers 4-5 | 116 | n/a | 47&186 | 6 | 99 | n/a | 63 | 81 | n/a | 150 | 32 | n/a |
| Clearing-chambers 4-5 | 46 | n/a | 26&66 | 6 | 39 | n/a | 63 | 32 | n/a | 150 | 13 | n/a |
| Hopper areas | 8 | n/a | 2&13 | 6 | 7 | n/a | 63 | 6 | n/a | 150 | 3 | n/a |
| Stem picker | 27 | 3 | 24-30 | 6 | 23 | 0 | 63 | 19 | 2 | 150 | 11 | 1 |
| e) Fumigation of two non-certified chambers (walnut, shelled and in-shell): | | | | | | | | | | | | |
| Cracking-workers | 1141 | 269 | 933-1789 | 6 | 978 | 231 | 70 | 887 | 209 | n/a | n/a | n/a |
| Sorting-workers | 593 | 116 | 397-770 | 6 | 508 | 99 | 70 | 461 | 90 | n/a | n/a | n/a |
| Fumigators | 559 | 446 | 123-1123 | 6 | 479 | 382 | 70 | 316 | 252 | 185 | 129 | 103 |
| Cleaning-fumigator | 80 | n/a | n/a | 6 | 69 | n/a | 70 | 45 | n/a | 185 | 18 | n/a |
| Cleaning-sort 1-3 | 889 | 185 | 723-1089 | 6 | 762 | 159 | 70 | 691 | 144 | n/a | n/a | n/a |
| Bulk casing worker | 856 | n/a | n/a | 6 | 734 | n/a | 70 | 666 | n/a | n/a | n/a | n/a |
| In-shell-packer 1-2 | 972 | n/a | 933&1011 | 6 | 833 | n/a | 70 | 756 | n/a | n/a | n/a | n/a |
| Hopper operator | 778 | n/a | n/a | 6 | 667 | n/a | 70 | 605 | n/a | n/a | n/a | n/a |
| Fumigator | 225 | n/a | n/a | 6 | 193 | n/a | 70 | 127 | n/a | 185 | 52 | n/a |
| Area sampling: | | | | | | | | | | | | |
| Fumigatorium | 75 | n/a | n/a | 6 | 64 | n/a | 70 | 42 | n/a | 185 | 17 | n/a |
| Sorting area 1-2 | 323 | n/a | 117&529 | 6 | 277 | n/a | 70 | 251 | n/a | n/a | n/a | n/a |
| Cracking area | 1089 | n/a | n/a | 6 | 933 | n/a | 70 | 847 | n/a | n/a | n/a | n/a |
| Vac. chamber area | 1,789 | n/a | n/a | 6 | 1533 | n/a | 70 | 1391 | n/a | n/a | n/a | n/a |
| Cleaning building fumigator | 802 | n/a | n/a | 6 | 687 | n/a | 70 | 453 | n/a | 185 | 185 | n/a |
| f) Sea van aeration (dried unpackaged prunes): | | | | | | | | | | | | |
| Upwind of sea van | 9 | n/a | n/a | 6 | 8 | n/a | 70 | 7 | n/a | n/a | n/a | n/a |
| Downwind-centers1-3 | 18 | 13 | 8-32 | 6 | 15 | 11 | 70 | 14 | 10 | n/a | n/a | n/a |
| Downwind-left1-3, right1-3 | 17 | 12 | 7-41 | 6 | 15 | 10 | 70 | 13 | 9 | n/a | n/a | n/a |

Table 11 (continued 5). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| 18. Fumigation of cherries for export (T.30, 5) | | | | | | | | | | | | |
| Control room: start-up | 171 | 147 | 3-366 | 5 | 122 | 105 | n/a | n/a | n/a | n/a | n/a | n/a |
| Control room: left overnight | 11 | 10 | 2-26 | 5 | 8 | 7 | n/a | n/a | n/a | n/a | n/a | n/a |
| Fumigators, start-up | 267 | 306 | 79-877 | 5 | 191 | 219 | n/a | n/a | n/a | n/a | n/a | n/a |
| Fumigators, closing-up | 327 | n/a | 219&435 | 5 | 234 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Fumigators, opening-up | 58 | 46 | 1-124 | 5 | 41 | 33 | n/a | n/a | n/a | n/a | n/a | n/a |
| Forklift drivers | 11 | 14 | 4-47 | 5 | 8 | 10 | n/a | n/a | n/a | n/a | n/a | n/a |
| Sorters | 123 | 72 | 69-337 | 5 | 88 | 51 | n/a | n/a | n/a | n/a | n/a | n/a |
| Compliance monitoring study: dump stations | 18 | 7 | 9-27 | 5 | 13 | 5 | n/a | n/a | n/a | n/a | n/a | n/a |
| 19. Methyl bromide air monitoring studies at a walnut processing facility (T.31; 6) | | | | | | | | | | | | |
| a) Worker exposure studies | | | | | | | | | | | | |
| Bulk packaging | 39 | 28 | 1-74 | 6 | 33 | 24 | 75 | 33 | 23 | n/a | n/a | n/a |
| Cleaning plant | 233 | 165 | 1-448 | 6 | 200 | 141 | 75 | 194 | 138 | n/a | n/a | n/a |
| Dock 5 | 500 | n/a | n/a | 6 | 429 | n/a | 75 | 417 | n/a | n/a | n/a | n/a |
| Fumigatorium | 45 | 50 | 1-106 | 6 | 39 | 43 | 75 | 27 | 31 | 180 | 10 | 11 |
| Packaging | 62 | n/a | 44&80 | 6 | 53 | n/a | 75 | 52 | n/a | n/a | n/a | n/a |
| Vacuum chamber | 283 | 216 | 92-636 | 6 | 243 | 185 | 75 | 236 | 180 | n/a | n/a | n/a |
| Sorting | 39 | 17 | 14-70 | 6 | 33 | 15 | 75 | 33 | 14 | n/a | n/a | n/a |
| Special cracking | 62 | 56 | 1-170 | 6 | 53 | 48 | 75 | 52 | 47 | n/a | n/a | n/a |
| b) Area samples | | | | | | | | | | | | |
| Meats pool | 71 | 53 | 12-126 | 2 | 20 | 15 | n/a | n/a | n/a | n/a | n/a | n/a |
| Warehouse/warehouse isle | 53 | 18 | 26-66 | 2 | 15 | 5 | n/a | n/a | n/a | n/a | n/a | n/a |
| Sorting line | 57 | 46 | 2-86 | 2 | 16 | 13 | n/a | n/a | n/a | n/a | n/a | n/a |
| West alleyway | 28 | n/a | n/a | 2 | 8 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| West cage door | 20 | n/a | n/a | 2 | 6 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| East alleyway | 6 | n/a | n/a | 2 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| East cage door | 6 | n/a | n/a | 2 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| c) On-site ambient air monitoring | | | | | | | | | | | | |
| Vicinity of chambers (10/28/93 and 11/19/93 | 171 | 174 | 11-435 | 2 | 49 | 50 | n/a | n/a | n/a | n/a | n/a | n/a |
| Chamber: Within 20' of the inj apparatus | 4100 | n/a | 1400&6800 | 2 | 1171 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Fence and gate areas (12/16/93) | 2 | 2 | 1-5 | 2 | 0.6 | 0.6 | n/a | n/a | n/a | n/a | n/a | n/a |
| Chambers-Butler (12/20/93) | 576 | 907 | 32-1933 | 2 | 165 | 259 | n/a | n/a | n/a | n/a | n/a | n/a |
| Fence and gate areas-east & north (12/20/93) | 2 | 1 | 2-5 | 2 | 0.6 | 0.3 | n/a | n/a | n/a | n/a | n/a | n/a |
| Chambers-Polygon&Butler (12/20/93) | 5 | 4 | 2-13 | 2 | 1 | 1 | n/a | n/a | n/a | n/a | n/a | n/a |
| Fence and gates-south & west (12/20/93) | 3 | 0.7 | 2-4 | 2 | 0.9 | 0.2 | n/a | n/a | n/a | n/a | n/a | n/a |

Table 11 (continued 6). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| Chambers-Butler (3/11/94) | 548 | 796 | 81-1467 | 2 | 157 | 227 | n/a | n/a | n/a | n/a | n/a | n/a |
| Chambers-Butler (3/17/94) | 17 | 18.5 | 2-47 | 2 | 5 | 5 | n/a | n/a | n/a | n/a | n/a | n/a |
| Fence (3/17/94) | 14 | 18.6 | 1-35 | 2 | 4 | 5 | n/a | n/a | n/a | n/a | n/a | n/a |
| Lamp post (10/25-26/94) | 5 | n/a | 3.8&6.3 | 2 | 1 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| North fence (10/25-26/94) | 14 | n/a | 5.8&21.9 | 2 | 4 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| North gate (10/25-26/94) | 6 | n/a | 3.6&7.9 | 2 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Pallets (10/25-25/94) | 36 | n/a | 8.9&64 | 2 | 10 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Polygon fence (10/25-26/94) | 13 | n/a | 3.7&27.6 | 2 | 4 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Polygon ramp (10/25-26/94) | 60 | n/a | 47.2&72 | 2 | 17 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Rooftop (10/25-26/94) | 7 | n/a | 1&13.2 | 2 | 2 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Scale house (10/25-26/94) | 19 | n/a | 12.3&24.9 | 2 | 5 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| South center&west fences (10/25-26/94) | 20 | 18 | 3.3-45.7 | 2 | 6 | 5 | n/a | n/a | n/a | n/a | n/a | n/a |
| Storage area (10/25-26/94) | 4 | n/a | 3.3&4.3 | 2 | 1 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Warehouse dock (12/25-26/94) | 111 | n/a | 24.8&198 | 2 | 32 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| West fence (12/25-26/94) | 10 | n/a | 8.6&12.2 | 2 | 3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| d) Compliance monitoring: | | | | | | | | | | | | |
| Sorting line in cleaning plant | 318 | 28 | 287-343 | 6 | 273 | 24 | 75 | 265 | 23 | n/a | n/a | n/a |
| Cello pack. of in-shell walnuts in main bldg. | 355 | 26 | 326-375 | 6 | 304 | 22 | 75 | 296 | 22 | n/a | n/a | n/a |
| Bulk pack. of in-shell walnuts in main bldg. | 243 | n/a | 242&245 | 6 | 208 | n/a | 75 | 203 | n/a | n/a | n/a | n/a |
| Truck dumping work station near dock 5: | | | | | | | | | | | | |
| Foreman's desk top | 369 | n/a | n/a | 6 | 316 | n/a | 75 | 308 | n/a | 180 | 182 | n/a |
| Foreman's desk, phone box shelf top | 28 | n/a | n/a | 6 | 24 | n/a | 75 | 23 | n/a | 180 | 14 | n/a |
| Fence between chambers 2 and 3 | 479 | n/a | n/a | 2 | 137 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 20. Fumigation and aeration at a brewery facility (T.32; 7) | | | | | | | | | | | | |
| a) Applicators | | | | | | | | | | | | |
| Entry and reentry to open canisters/cylinders | 28.9 | n/a | n/a | 2 | 8.3 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Area sample (door to buffer zone) | 42 | n/a | n/a | 2 | 12 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| b) Aerators | | | | | | | | | | | | |
| Aerators | 25 | 24 | 24&25 | 2 | 7 | 7 | n/a | n/a | n/a | n/a | n/a | n/a |
| Area sample (left of entrance door) | 173 | n/a | n/a | 2 | 49 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Area sample (on applicator's truck) | 100 | n/a | n/a | 2 | 29 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

Table 11 (continued 7). Acute and non-acute exposures of persons in California to methyl bromide*.

| Number/ Type of application | Acute exposure (ppb) /24-hour period | | | Subacute exp. (ppb) /7-day period | | | Subchronic exp. (ppb) /90-day period | | | Chronic exp. (ppb) /365-day period | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Avg. | STDEV | Range | Days | Avg. | STDEV | Days | Avg. | STDEV | Days | Avg. | STDEV |
| 21. Outdoor and indoor MB air concentrations near fumigated houses (T.33; 8.a) | | | | | | | | | | | | |
| Outdoor air - 20 feet from the fumi. house | 522 | n/a | 38-2990 | 7 | 522 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Indoor air - rooms closest to the fum house | 24 | n/a | 24-406 | 7 | 24 | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 22. Downwind outdoor and indoor MB air concentrations during aeration of fumigated houses (T.34; 8.b) | | | | | | | | | | | | |
| Outdoor air (adjusted) | | | | | | | | | | | | |
| 10 feet | 296 | n/a | 24-1064 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 50 feet | 80 | n/a | 24-208 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| 100 feet | 40 | n/a | 24-74 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Indoor air (adjusted) | 60 | n/a | 24-168 | n/a | n/a | n/a | n/a | n/a | n/a | | | |
| 23. Exposure of residents to MB in fumigated houses (T.37; 9) | | | | | | | | | | | | |
| Southern CA (1.5 lbs MB/1,000 ft3) | 210 | n/a | n/a | 7 | 172 | 146 | n/a | n/a | n/a | n/a | n/a | n/a |
| Northern CA (3.0 lbs MB/1,000 ft3) | 210 | n/a | n/a | 7 | 344 | 294 | n/a | n/a | n/a | n/a | n/a | n/a |
| 24. Exposure of residents to MB during commodity fumigation (T.38; 10) | | | | | | | | | | | | |
| Low range of exposure days | 210 | n/a | n/a | 3 | 90 | n/a | 30 | 70 | n/a | 150 | 86 | n/a |
| High range of exposure days | 210 | n/a | n/a | 6 | 180 | n/a | 75 | 175 | n/a | 185 | 106 | n/a |
| 25. Exposure of residents to MB from living near fumigated fields (Appendix D) | | | | | | | | | | | | |
| Residents | 210 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

**Notes:**
Most MB exposure studies, except for some modified soil injection fumigations, were conducted as bases to formulate proposed permit comditions. Listed below are studies that were conducted before DPR issued suggested MB permit conditions. Some conditions used in these studies were not in compliance with current suggested permit conditions, such as an application of MB was done inside a greenhouse, an aeration period was shorter than that recommended in permit conditions, chambers were not pressure tested, or chambers did not have standard stacks.

**Examples of MB fumigations that were not in compliance with current suggested permit conditions:**
Nursery potting soil fumigation, greenhouse soil fumigation, fumigation of grain products (chambers, vans, etc.), fumigation of dried fruit and tree nut products, fumigation at a walnut processing facility, fumigation at a brewery facility.

Even though those fumigation studies were not conducted in compliance with current suggested permit conditions, exposure data are shown in this document in order to indicate some problem areas for further improvement. It is desirable to obtain exposure data from studies that are conducted in compliance with current suggested permit conditions.

## EXPOSURE APPRAISAL

The exposure appraisal section contains information regarding the quality of exposure studies and the adequacy of submitted reports. This section also briefly describes uncertainty of default factors used in the calculation of exposure estimates. The section also provides some suggestions on how to obtain better exposure estimates for the MB risk assessment.

None of the submitted MB exposure studies met requirements set forth in Subdivision U (U.S. EPA, 1986b) regarding the number of replicates and locations of the studies, i.e., three locations and five replicates per location for each work task monitored. Many studies provided more than five replicates for each work task, but a majority of the field studies provide replicates ranging from one to three replicates. In most cases, these replicates were from one location. This occurred because DPR had requested expedited development of exposure monitoring data to revise the use permits. Additionally, many studies were not conducted in compliance with GLP standards indicated in 40 CFR 160 (U.S. EPA, 1998).

Reports of the studies were gradually submitted to the Department in the form of interim, internal, or draft reports. Only a few reports were finalized using a format similar to the PR Notice 86-5 (U.S. EPA, 1986c). Currently, many reports are still classified as interim or internal reports; finalizing these reports may not be accomplished by registrants in the foreseeable future. Nonetheless, these exposure data are shown in this exposure assessment document because registrants were asked by DPR to produce them and the studies were conducted in California.

A field fortification recovery study was not carried out in many of the exposure studies. This may due to the fact that MB has a very high vapor pressure. It is extremely difficult to conduct a field fortification recovery study. Several laboratory recovery studies were performed and the monitoring data were adjusted for recoveries. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). Reports of several studies did not disclose application rates of MB. Authors could not make corrections regarding application rates and fortification recoveries. Thus, MB concentrations for some of those studies shown in this document could be lower than what they should be in actual work environment.

Frequency and duration of exposure are important factors employed in the calculation of non-acute exposure estimates. DPR realizes that registrants can provide data on frequency and duration of exposures because they have close contacts or business relationships with dealers, pest control operators or other users. That was why DPR issued several requests to registrants in November of 1997 for such data. The Department has received some information essential for the estimation of acute and non-acute exposures. DPR has made it clear in those letters that if registrants fail to provide requested data, the Department will derive default factors based upon available information and professional judgment. Authors of this document have conducted data searches, utilized survey results, as well as, consulted with knowledgeable persons on the use of MB. The default factors were established and used in the calculation of subacute and non-acute exposure estimates.

Many exposure data were obtained from studies employing short monitoring periods and then amortized to the 24-hour time-weighted average. These amortized exposure data could overestimate or underestimate the actual exposure.

Exposure estimates shown in this document are generally for specific work tasks and exposure scenarios. In other words, the exposure estimated for forklift drivers in a commodity fumigation or for applicators in a greenhouse fumigation was based on a specific time period used to perform those work tasks. It did not take into account the exposure to MB the remainder of the workday if those workers performed other duties. Also, the calculated maximum duration of a workday for acute exposure was based on sources other than current permit conditions. There is a good possibility that the acute exposure was underestimated because workers might work overtime during the peak use season. In contrast, we do not know the degrees of overestimation of exposure when a study was not conducted in compliance with current suggested permit conditions. It is desirable for the Department to obtain exposure data from studies that are conducted in compliance with the permit conditions.

Information on some of the variables mentioned in this section is intended to be qualitative in nature. It is difficult to judge quantitatively how these variables might affect MOE. For example, if the application rate was not mentioned, the rate could be at the maximum application rate. Hence, this variable would have no effect on exposure or MOE. Furthermore, we do not know if more data on frequency and duration of exposure would affect MOE and to what extent. We do not have sufficient background information to assign numbers to those variables. If we do so, it will cause some uncertainty concerning those assigned numbers.

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## REFERENCES


Air Toxics Limited. 1995. Worker health and safety and ambient air monitoring at Diamond Walnut Growers, Inc. 1992-1994. MB Submission 0265.

Alexeeff, G. V., and Kilgore, W. W. 1983. Methyl bromide. *Residue Reviews* 88:101-153.

Anonymous. 1992. MB monitoring: Farmers rice coop long-term air monitoring possible exposure - forklift operators. MB Submission 0156.

Biermann, H. W., and Barry, T. 1999. Evaluation of charcoal tube and SUMMA canister recoveries for methyl bromide air sampling. Environmental and Pest Management Branch, DPR. EH 99-02.

Bloomcamp, C. L., Scheffrahn, R. H., and Su, N. Y. 1991. Indoor airborne residues to methyl bromide and sulfuryl fluoride in fumigated houses following aeration. DPN 50223-019, record number 96537.

Bond, J. A., Dutcher J. S., Medinsky, M. A., Henderson, R. F., and Birnbaum L. S. 1985. Disposition of $^{14}$C-methyl bromide in rats after inhalation. *Toxicol. Appl. Pharmacol*. 78:259-267. (in DPN 123-135, record number 89719).

Budavari, S., O'Neil, M. J., Smith, A., Heckelman, P. E. (eds.). 1989. *The Merck Index*. Eleventh edition. Merck & Co., Inc., Rahway, NJ. 1606 pp.

California Department of Food and Agriculture (CDFA). 1984a. Determination of methyl bromide residues in strawberries after a commercial fumigation. DPN 123-089.

CDFA. 1984b. Methyl bromide residues in wheat and flour during fumigation, storage, clearing, and milling in a commercial milling facility. DPN 123-089.

Danse, L. H. J. C., van Velsen, F. L., and van der Heijden, C. A. 1984. Methyl bromide: Carcinogenic effects in the rat forestomach. *Toxicol. Appl. Pharmacol*. 72:262-271. (in DPN 123-043, record number 913094).

Deschamps, F. J., and Turpin, J. C. 1996. Methyl bromide intoxication during grain store fumigation. *Occup. Med*. 46: 89-90.

Donahue, J. M. 1997. DPR letters dated November 12. (Letters were sent to six MB registrants requesting data on frequency and duration of exposure). WH&S, DPR.


(DPN = Data Package Number, which is unique for DPR; MB Submission = Reports that were not assigned a DPN)

Environmental Monitoring and Pest Management Branch (EM&PM). 1998. 1995 Pesticide Use Report: Use of MB in structural fumigation in California. DPR.

Fairall, R. J., and Scudamore, K. A. 1980. Determination of residual methyl bromide in fumigated commodities using derivative gas chromatography. *Analyst* 105:251-256.

Federal Register. 1991. Code of Federal Regulations, 40 Part 180.3 (c)(2). Office of the Federal Register, National Archives and Records Administration. U.S. Government Printing Office, Washington, D.C.

Gibbons, D. 1992. A letter dated May 11 to John Sansone of SCC Products regarding the MB data from a joint structural fumigation study in Los Angeles. WH&S, DPR. HSM-920002.

Gibbons, D. B. 1994. Department of Pesticide Regulation monitoring of methyl bromide fumigation at Anheuser-Busch Brewery. A memorandum dated December 27 to Dane Starling of Anheuser-Busch, Inc. HSM-94002.

Gibbons, D. B. 1995. Compliance monitoring at Diamond Walnut. A memorandum dated November 2 to Chuck Andrews of the Pesticide Enforcement Branch, DPR. HSM-95001.

Gibbons, D. B. 1996. Methyl bromide monitoring study at the cherry processing building. A memorandum dated June 27 to Greg Costa of Felix Costa & Son. HSM-96001.

Gibbons, D. B., Fong, H. R., Segawa, R., Powell, S., and Ross, J. 1996a. Methyl bromide concentrations in air near fumigated single-family houses. WH&S, DPR. HS-1717.

Gibbons, D. B., Fong, H. R., Segawa, R., Powell, S., and Ross, J. 1996b. Methyl bromide concentrations in air downwind during aeration of fumigated single-family houses. WH&S, DPR. HS-1713.

Harris, M. C., Harvey, J. M., and Fouse, D.C. 1983. Penetration and retention of methyl bromide in packaged table grapes. *American Journal of Enology and Viticulture* 35:5-8.

Hartsell, P. L., Nelson, H. P., and Vail, P. V. 1984a. Walnut research reports. DPN 123-089.

Hartsell, P. L., Nelson, H. P., and Stanley, W. L. 1984b. Methyl bromide fumigation of almonds and almond products. DPN 123-089.

Hartsell, P. L., Nelson, H. D., Tebbets, J. C., and Vail, P. V. 1986. Methyl bromide fumigation treatments for pistachio nuts to decrease residues and control navel orangeworm, Amyelois transitellia (Lepidoptera: Pyralidae). *J. Econ. Entomol*. 79:1299-1302.

Hartsell, P. L., Tebbets, J. C., and Ostrom, J. K. 1988. Annual report of Almond Board of California. Tree and Crop Research, project-89-59.

Hartsell, P. L., Obenauf, G. L., Gunnerson, R. E., and Mosebar, F. A. 1992. Methyl bromide residue studies on dried fruit and nuts. Prune, Raisin and Walnut Marketing Board. MB Submission 0078.

Haskell, D. 1998a. Methyl bromide fumigation with various commodities. A memorandum dated May 11 to Thomas Thongsinthusak. WH&S, DPR. HSM-98003.

Haskell, D. 1998b. Response to DPR request for additional information regarding frequency and duration of methyl bromide fumigations. A memorandum dated August 24 to Thomas Thongsinthusak. WH&S, DPR. HSM-98006.

Helliker, P. E. 1999. Status of methyl bromide permit conditions. A letter to interested parties. DPR. August 31.

Hezemans-Boer, M., Toonstra, J., Meulenbelt, J., Zwaveling, J. H., Sangster, B., and van Vloten W. A. 1988. Skin lesions due to exposure to methyl bromide. *Arch. Dermatol*. 124: 917-921.

Hosoda, E. 1992. Methyl bromide monitoring. The Grain Product Group. Cal Ag-Industrial Supply, Inc.

Ingram, F. R. 1951. Methyl bromide fumigation and control in the date-packing industry. *Arch. Ind. Hyg. Occup. Med.* 4:193-198.

Jandel Scientific. 1994. SigmaPlot™ for Windows: Scientific Graphing Software. P.O. Box 7005, San Rafael, California.

Jaskot, R. H., Grose, E. C., Most, B. M., Menache, M. G., Williams, T. B., and Roycroft, J. J. 1988. The distribution and toxicological effects of inhaled methyl bromide in the rat. *J. Am. Coll. Toxicol*. 7:631-642. (in DPN 123-135, record number 89717).

Johnson, B. 1992. Estimating the ratio between wall volume and house volume. A memorandum dated April 8, 1992 to John Sanders. DPR.

Johnstone, R. T. 1944. Methyl bromide intoxication. *Industr. Med*. 14:495-497.

Jordi, A. U. 1953. Absorption of methyl bromide through the intact skin: A report of one fatal and two non-fatal cases. *Airspace Med. J.* 24:536-539.

King, J. R., Benschoter, C. A., and Burditt, A. K. 1981. Residues of methyl bromide in fumigated grapefruit determined by a rapid, headspace assay. DPN 123-116.

Le Goupil, M. 1932. Les proprieties insecticide du bromure de methyl. *Rev. Pathol. Veg. Entomol. Agr. Fr*. 19:169.

Longley, E. O., and Jones, A. T. 1965. Methyl bromide poisoning in man. *Ind. Med*. *Surg*. 34:499-502.

MacDonald, A. C., Monro, I. C, and Scott, G. I. 1950. Fatal case of poisoning due to inhalation of methyl bromide. *Brit. Med. J*. 2:441-442.

Malone, B. 1970. Isolation of methyl bromide from food raw materials for gas chromatographic quantitation. *J. AOAC* 53.

McDougal, J. N., Jepson, G. W., Clewell III, H. J., and Andersen, M. E. 1985. Dermal absorption of dihalomethane vapors. *Toxicol. Appl. Pharmacol*. 79: 150-158.

McDougal, J. N., Jepson, G. W., Clewell III, H. J., Gargas, M. L., and Andersen, M. E. 1990. Dermal absorption of organic chemical vapors in rats and humans. *Fund. Appl. Toxicol*. 14: 299-308.

Medinsky, M. A., Bond, J. A., Dutcher, J. S., and Birnbaum, L. S. 1984. Disposition of [$^{14}$C] methyl bromide in Fischer-344 rats after oral or intraperitoneal administration. *Toxicology* 32:187-196. (in DPN 123-135, record number 89720).

Medinsky, M. A., Dutcher, J. S., Bond, J. A., Henderson, R. F., Mauderly, J. L., Snipes, M. B., Mewhinney, J. A., Cheng, Y. S., and Birnbaum, L. S. 1985. Uptake and excretion of [$^{14}$C] methyl bromide as influenced by exposure concentration. *Toxicol. Appl. Pharmacol*. 78:215-225. (in DPN 123-135, record number 89718).

Mehler, L. 1997. Summary: Illnesses associated with exposure to methyl bromide alone and in combination as reported by physicians in California from 1982 to 1995. Pesticide Illness Surveillance Program, WH&S, DPR.

Meister, R. T. (ed.). 1995. *Farm Chemicals Handbook*. Meister Publishing Company, Willoughby, OH.

Mezel, P., Bourret, J., and Roche, L. 1948. Poisoning of the whole family of five persons following upon the use of methyl bromide to disinfect a dwelling. Three deaths. *Ind. Hyg. Toxicol.* 23:527.

Nelson, L. 1992. Methyl bromide preliminary risk characterization. A memo dated February 11 to Jim Wells, DPR.

Nelson, H. D., Hartsell, P. L., Armstrong, J. W., Down, L. L., and Lee, R. 1975. Annual Report, Almond Board of California-Project 75-I. MB Submission 0077.

NIOSH. 1987. NIOSH Respirator Decision Logic. U.S. Department and Human Services, Public Health Services, Center for Disease Control, National Institute for Occupational Safety and Health. May.

Obenauf, G. L. 1992. Prune, Raisin and Walnut Marketing Boards. MB Submission 0079.

Pest Control Operators of California (PCOC). 1994. California structural fumigation pest control industry standard: Tarpaulin removal aeration time. Pest Control Operators of California, Sacramento, California.

Raabe, O. G. (University of California, Davis). 1986. Inhalation uptake of selected chemical vapors at trace levels. The Biological Effects Research Section, California Air Resources Board (CARB), Sacramento, CA. CARB Contract No. A3-132-33.

Raabe, O. G. (University of California, Davis). 1988. Retention and metabolism of toxics. inhalation uptake of xenobiotic vapors by people. The Biological Effects Research Section, California Air Resources Board, Sacramento, CA. CARB Contract No. A5-155-33.

Radian Corporation. 1992. Determination of methyl bromide exposure during dried fruit and tree nut fumigation practices, volumes I & II. MB Submission 0200.

Rathus, E. M., and Randy, P. J. 1961. Methyl bromide poisoning. *Brit. J. Ind.. Med*. 18:53-57.

Reuzel, P. G. J., Kuper, C. F., Dreef-van der Meulen, H. C., and Hollanders, V. M. H. (Civo Institutes TNO). 1987. Chronic (29-month) inhalation toxicity and carcinogenicity study of methyl bromide in rats. DPN 123-084, record number 59184; DPN 123-147, record number 116337; DPN 123-148, record number 120402; DPN 123-148, record number 120406; and DPN 123-166, record number 133417.

Reuzel, R. G. J., Dreef-van der Meulen, H. C., Hollanders, V. M .H., Kuper, C. F., Feron, V. J., and van der Heijden, C. A. 1991. Chronic inhalation toxicity and carcinogenicity study of methyl bromide in Wistar rats. *Food Chem. Toxicol*. 29:31-39.

Richmond, D. 1997. Priority investigations as a result of evacuation after the use of methyl bromide in California from 1982 to 1995 (Personal communication). Pesticide Illness Surveillance Program, WH&S, DPR.

Riggs, D. 1992. California Strawberry Advisory Board. Methyl bromide poisoning. MB Submission 0153.

Riihimaki, V., and Pfaffli, P. 1978. Percutaneous absorption of solvent vapors in man. *Scand. J. Work Environ. & Health* 4: 73-85.

Ross, J. H., and Gibbons, D. B. 1992. Cal/EPA, Department of Pesticide Regulation methodology for measuring methyl bromide exposure to application personnel and other potentially exposed workers (6/12). Cal/EPA, Department of Pesticide Regulation. HSM-980001.

Sanders, J. S. 1998. Definition of exposure constituting chronic and subchronic. A memorandum dated March 10 to G. Patterson of the Medical Toxicology Branch, DPR. HSM-980009.

Sanders, J. S., and Andrews, C. M. 1998. Installation of irrigation pipe during soil fumigation. A letter dated July 7 to County Agricultural Commissioners. DPR. CAC letter WHS 98-04.

Sansone, J. S. 1998. Typical methyl bromide structural fumigation rates in California. Phone conversations with Dennis Gibbons and Tom Thongsinthusak on June 5.

Schraffrahn, R. H., Bloomcamp, C. L., and Su, N.-Y. 1992. Indoor airborne residues of methyl bromide and sulfuryl fluoride following aeration of fumigated houses. *Indoor Air* 2:78-83.

Sell, C. R., Klag, N. G., and Burditt, A. K. 1987. Methyl bromide residues in fresh cherries: Effects of parameters of fumigation. *Pesticide Science* 23:41-49.

Siemer & Associates, Inc. 1992a. Shallow-shank tarp method of methyl bromide fumigation worker exposure. Alliance of the Methyl Bromide Industry (AMBI). MB Submission 0239 A-D (SM924096A-D).

Siemer & Associates, Inc. 1992b. Non-tarp deep injection for measurement of methyl bromide exposure to the applicator, applicator assistant and cultipacker tractor driver (SM924096B).

Siemer & Associates, Inc. 1992c. AMBI: Shallow shank-tarped bed fumigation assessment (SM924096C, M).

Siemer & Associates, Inc. 1992d. Nursery Panel methyl bromide worker exposure assessment from potting soil fumigation (SM924099B).

Siemer & Associates, Inc. 1992e. Nursery Panel Methyl Bromide Task Force: Worker exposure and drift assessment (SM924099A1).

Siemer & Associates, Inc. 1993a. Deep shank bed fumigation using mitigation measures to limit worker exposure (SM934104-1.2).

Siemer & Associates, Inc. 1993b. Deep shank, non-tarped fumigation-mitigation of methyl bromide worker exposure and offsite drift (SM934104.1-2, SM934104.2-1, vol. 1-2).

Siemer & Associates, Inc. 1993c. Tarped-bed fumigation - mitigation of methyl bromide worker exposure (SM934104.1M).

Siemer & Associates, Inc. 1994. Tarp-bed fumigation for measurement of methyl bromide exposure, to the applicator, applicator assistant, shovelman, irrigation pipelayers and pipe drive positions (SM934110). MB Submission 0266 B-C.

Sinclair, W. B., and Lindgren, D. 1952. Effect of load in fumatorium on sorption of fumigants. Paper 728. University of California Citrus Experimental Station, Riverside, California.

Singh, G., Rippon, L. E., and Gilbert, W. S. 1982. Methyl bromide and organic bromide residues in avocados after fumigation and storage. *Aust. J. Exp. Agric. Anim. Husb*. 22:343-347.

Soderstrom, E. L., Brandl, D. G., Hartsell, P. L., and Mackey, B. 1991. Fumigants as treatments for harvested citrus fruits infested with Asynonychus godmani (Coleoptera: Curculionidae). *J. Econ. Entomol*. 84:936-941.

Soil Chemicals Corp. 1980. Application and fumigation data for 24-c registration of methyl bromide for structural fumigation. DPN 123-025, record number 29764.

Stegmiller, F. R., and Lee, H. 1992. Inhalation exposure of applicators and handlers of methyl bromide treated fresh cherries for export 1992. Bioentech Incorporated and Bolsa Research Associates, Inc.

Tebbets, J. S., Hartsell, P. L., Nelson, H. D., and Tebbets, J. C. 1983. Methyl bromide fumigation of tree fruits for control of the Mediterranean Fruit Fly: Concentration, sorption and residues. *J. Agric. Food Chem*. March:247-249.

TriCal, Inc. 1987. Response/California Notice 87-5: Risk assessment/methyl bromide. DPN 123-099, record numbers 64748 to 64753.

TriCal, Inc. 1990. Worker exposure data-12" tarpless. DPN 123-119, record numbers 95086 and 95087 (Also, DPN 123-120)

TriCal, Inc. 1993a. Tarp removal worker exposure. Vol. 1-2 (TC 211).

TriCal, Inc. 1993b. New high barrier film evaluation studies (TC233.1, TC233.2, TC233.3).

U.S. EPA. 1986a. Guidance for the registration of pesticide products containing methyl bromide as the active ingredient. Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 1986b. Pesticide Assessment Guidelines. Subdivision U: Applicator Exposure Monitoring. OPP/HED, Washington, D.C.

U.S. EPA. 1986c. PR Notice 86-5. Notice to producers, formulators, distributors and registrants. Standard format for data submitted under the FIFRA and certain provision of the FFDCA. U.S. Environmental Protection Agency, Washington, D.C.

U.S. EPA. 1992. Bromomethane, 4/6/92, Integrated Risk Information System (IRIS), U.S. Environmental Protection Agency, Washington, D.C.

von Oettingen, W. F. 1946. The toxicity and potential dangers of methyl bromide with special reference to its use in the chemical industry, in fire extinguishers, and in fumigation. *NIH Bulletin No. 185*, pp. 1-41.

Watrous, R. M. 1942. Methyl bromide local and mild systemic effects. *Industr. Med*. 11:575-579.

Watson, R. T., Albritton, D. L., Andersen, S. O., and Lee-Bapty, S. 1992. Synthesis report of the methyl bromide interim scientific assessment and methyl bromide interim technology and economic assessment. Montreal Protocol Assessment Supplement. Requested by United Nations Environment Programme on behalf of the Contracting Parties to the Montreal Protocol. June 25.

Wieczorek, H. 1985. Evaluation of low exposure to styrene. II. Dermal absorption of styrene vapors in humans under experimental conditions. *Int. Arch. Environ. Health.* 57: 71-75.

Zwaveling, J. H., de Kort, W. L. A. M., Meulenbelt, J., Hezemans-Boer, M., van Vloten, W. A., and Sanster, B. 1987. Exposure of the skin to methyl bromide: A study of six cases occupationally exposed to high concentrations during fumigation. *Human Toxicol*. 6:491-495.

# Appendix A
# Frequency and Duration of Exposure

Table 12. Frequency and duration of acute and non-acute exposures for workers and residents.

| | | Adjustment rate | Hours/workday (ref.) | | Workdays (ref.) | | |
|---|---|---|---|---|---|---|---|
| Number | Work task | (lb. MB/A) (ref) | Acute | Subc-chronic* | /7 days | /90 days | /365 days |
| 1.a | *Shallow shank-tarped soil fumigation (broadcast) (T.13-17)* | | | | | | |
| | *Applicators (used Noble Plow shanks, 10-12")* | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Co-pilots | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Shovelmen: Employed by growers | 400 (1) | 5.8 (7) | n/a-n/a (6) | 3 (8) | n/a (6) | n/a (6) |
| | Tarpaulin removers: Employed by private companies | 400 (1) | 6 (6) | 6-n/a (6) | 5 (8) | 55 (8) | n/a (6) |
| | Tarpaulin removers: Employed by growers | 400 (1) | 2 (6) | n/a-n/a (6) | 2 (8) | n/a (6) | n/a (6) |
| | | | | | | | |
| 1.b | *Deep shank injection fumigation (broadcast) (T.18)* | | | | | | |
| | Applicators (used improved shank, 20-24") | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Co-pilots: Employed by application rigs | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Cultipacker tractor drivers: Employed by growers | 400 (1) | 5.8 (7) | n/a-n/a (6) | 6 (8) | n/a (6) | n/a (6) |
| | | | | | | | |
| 1.c | *Deep shank injection fumigation (Traver, etc., CA) (T.19)* | | | | | | |
| | Applicators (used forward curving inj. shank, cl. scraper, 24") | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Disc drivers: Employed by PCOs | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Cultipacker tractor drivers: Employed by growers | 400 (1) | 5.8 (7) | n/a-n/a (6) | 6 (7) | n/a (6) | n/a (6) |
| | Supervisor: Employed by PCOs | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | | | | | | | |
| 1.d | *Deep shank injection fumigation (Helm, CA) (T.20)* | | | | | | |
| | Applicators (used forward curving shank, 24") | 400 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Cultipackers: Employed by growers | 400 (1) | 5.8 (7) | n/a-n/a (6) | 6 (7) | n/a (6) | n/a (6) |
| | | | | | | | |
| 1.e | *Shallow shank-tarped bed fumigation (T.21)* | | | | | | |
| | Applicators (used modified shanks, 6-8") | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Co-pilots | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | | | | | | | |
| 1.f | *Tarped-bed fumigation: Mitigation of exposure (T.22)* | | | | | | |
| | Applicators (used Kennco Combi Superbedder, 14") | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Co-pilots | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Drivers: Employed by PCOs | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Drip tape layers: Employed by growers | 250 (1) | 5.8 (7) | n/a-n/a (6) | 3 (8) | n/a (6) | n/a (6) |

PCO = Pest control operator; n/a = Not applicable; T. = Table.

Adjustment rate = An application rate that was used to adjust air concentrations from a study using a different application rate.

Non-acute exposures include subacute, subchronic and chronic exposures.

* Exposure times as indicated were used, where applicable, for the calculation of daily subchronic and chronic exposures (Tables 13-31, 38).

Table 12 (cont. 1). Frequency and duration of acute and non-acute exposures for workers and residents.

| | | Adjustment rate | Hours/workday (ref.) | | Workdays (ref.) | | |
|---|---|---|---|---|---|---|---|
| Number | Work task | (lb. MB/A) (ref) | Acute | Subc-chronic* | /7 days | /90 days | /365 days |
| 1.g | *Shallow shank, tarped bed fumigation (T.23)* | | | | | | |
| | Applicators (used sweptback shank, 8") | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Co-pilots | 250 (1) | 5.8 (7) | 5.8-n/a (7) | 6 (7) | 40 (7) | n/a (7) |
| | Shovelmen: Employed by growers | 250 (1) | 5.8 (7) | n/a-n/a (6) | 3 (8) | n/a (6) | n/a (6) |
| | Pipelayers: Employed by growers | 250 (1) | 5.8 (7) | n/a-n/a (6) | 3 (8) | n/a (6) | n/a (6) |
| | Irrigation pipe tractor drivers: Employed by growers | 250 (1) | 5.8 (7) | n/a-n/a (6) | 3 (8) | n/a (6) | n/a (6) |
| | | | | | | | |
| 1.h | *Tarp removers (shallow shank, broadcast, HB, 10-12") (T.24)* | | | | | | |
| | Cutters: Growers | 400 (1) | 2 (6) | n/a-n/a (6) | 2 (8) | n/a (8) | n/a (6) |
| | Cutter: Employed by independent companies | 400 (1) | 6 (6) | 6-n/a (6) | 5 (8) | 30 (8) | n/a (6) |
| | Pullers: Employed by growers | 400 (1) | 2 (6) | n/a-n/a (6) | 2 (8) | n/a (8) | n/a (6) |
| | Puller: Employed by independent companies | 400 (1) | 6 (6) | 6-n/a (6) | 5 (8) | 30 (8) | n/a (6) |
| | | | | | | | |
| 1.i | *Tarp cutters and removers (T.25)* | | | | | | |
| | Cutters (Fum. Shallow, broadcast, VHB, Noble Plow shank, 10") | 400 (1) | 2 (6) | n/a-n/a (6) | 5 (8) | n/a (6) | n/a (6) |
| | Removers: Employed by growers | 400 (1) | 2 (6) | n/a-n/a (6) | 5 (8) | n/a (6) | n/a (6) |
| | Cutters and removers: Employed by independent companies | 400 (1) | 6 (6) | 6-n/a (6) | 5 (8) | 30 (8) | n/a (6) |
| | | | | | | | |
| 2.a | *Nursery potting soil fumigation (T.26)* | | | | | | |
| | Applicators (used perforated plastic hoses, 6-mil PE) | 0.6/$yd^3$ (3) | 1 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Applicator assistants | 0.6/$yd^3$ (3) | 1 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Tarp removers | 0.6/$yd^3$ (3) | 1 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Tractor drivers | 0.6/$yd^3$ (3) | 1 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Truck drivers | 0.6/$yd^3$ (3) | 1 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Potters | 0.6/$yd^3$ (3) | 3 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | | | | | | | |
| 2.b | *Greenhouse soil fumigation (T.27*) | | | | | | |
| | Applicators (used perforated plastic hoses, 1 mil HDT) | 450 (2) | 2 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Tarp venters | 450 (2) | 1 (6) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | Tarp removers | 450 (2) | 1 (7) | n/a-n/a (6) | 1 (6) | n/a (6) | n/a (6) |
| | | | | | | | |
| 3 | *Fumigation of grain products (chambers, vans, etc.) (T.28)* | | | | | | |
| | Applicators (6 mil PE, if used) | 6/1,000 $ft^3$(4) | 6 (6)[c] | 6.5-5 (6) | 5 (6) | 45 (6) | 180 (6) |
| | Aerators | 6/1,000 $ft^3$(4) | 6 (6)[c] | 6.5-5 (6) | 5 (6) | 45 (6) | 180 (6) |
| | Forklift drivers | 6/1,000 $ft^3$(4) | 1 (6) | 0.5-0.5 (6) | 5 (6) | 45 (6) | 180 (6) |
| | Rice processing workers (Warehouse) | 6/1,000 $ft^3$(4) | 6 (8) | n/a-n/a (6) | 5 (8) | n/a (6) | n/a (6) |

Table 12 (cont. 2). Frequency and duration of acute and non-acute exposures for workers and residents.

| | | Adjustment rate | Hours/workday (ref.) | | Workdays (ref.) | | |
|---|---|---|---|---|---|---|---|
| Number | Work task | (lb. MB/A) (ref) | Acute | Subc-chronic* | /7 days | /90 days | /365 days |
| 4 | *Fumigation of dried fruit & tree nut products (T.29)* | | | | | | |
| | *1. Sea van* | | | | | | |
| | Fumigators | 1.5/1,000 $ft^3$(4) | 1 (6) | n/a-n/a (6) | 2 (6) | n/a 6) | n/a (6) |
| | Fumigator observers | 1.5/1,000 $ft^3$(4) | 1 (6) | n/a-n/a (6) | 2 (6) | n/a (6) | n/a (6) |
| | Aeration | 1.5/1,000 $ft^3$(4) | 1 (8) | n/a-n/a (8) | 2 (6) | n/a (8) | n/a (8) |
| | Area sampling (15-foot downwind) | 1.5/1,000 $ft^3$(4) | 1 (8) | n/a-n/a (8) | 2 (8) | n/a (8) | n/a (8) |
| | | | | | | | |
| | *2. Chamber (dried prunes)* | | | | | | |
| | Forklift operators | 1.5/1,000 $ft^3$(4) | 0.5 (7) | n/a-n/a (6) | 3 (7) | n/a (7) | n/a (7) |
| | Fumigators | 1.5/1,000 $ft^3$(4) | 0.5 (7) | n/a-n/a (6) | 3 (7) | n/a (7) | n/a (7) |
| | 1-m from door | 1.5/1,000 $ft^3$(4) | 0.5 (7) | n/a-n/a (6) | 3 (7) | n/a (7) | n/a (7) |
| | 2 & 15 m from chamber | 1.5/1,000 $ft^3$(4) | 0.5 (7) | n/a-n/a (6) | 3 (7) | n/a (7) | n/a (7) |
| | Leak check, side seal | 1.5/1,000 $ft^3$(4) | 0.5 (7) | n/a-n/a (6) | 3 (7) | n/a (7) | n/a (7) |
| | | | | | | | |
| | *3. Big chamber fumigation (raisins)* | | | | | | |
| | Primary fumigators | 1.5/1,000 $ft^3$(4) | 3 (6)[c] | 2.5-2.5 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Secondary fumigators | 1.5/1,000 $ft^3$(4) | 3.5 (6)[c] | 2.5-2.5 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Aerators | 1.5/1,000 $ft^3$(4) | 3 (6)[c] | 2.5-2.5 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Forklift drivers | 1.5/1,000 $ft^3$(4) | 2.5 (6)[c] | 2-2 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Cathall operators | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Hopper operators | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Capper dumpers | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Inspectors | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Moister checkers | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Stem pickers | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Packers | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Shed-green forklift | 1.5/1,000 $ft^3$(4) | 2.5 (6)[c] | 2-2 (6) | 5 (6) | 60 (6)[a] | 20&170[b](6) |
| | Shed-blue tractor | 1.5/1,000 $ft^3$(4) | 2.5 (6)[c] | 2-2 (6) | 5 (7) | 60 (6)[a] | 20&170[b](6) |
| | Aeration-shed 604-606 | 1.5/1,000 $ft^3$(4) | 3 (8) | 2.5-2.5 (8) | 5 (8) | 60 (8) | 20&170[b](6) |
| | Capper area | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (6) | 5 (6) | 60 (6) | 20&170[b](6) |
| | Hopper area | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (6) | 5 (6) | 60 (6) | 20&170[b](6) |
| | Catchoff area | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (6) | 5 (6) | 60 (6) | 20&170[b](6) |
| | Side hopper area | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (6) | 5 (6) | 60 (6) | 20&170[b](6) |
| | Stem picker area | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (6) | 5 (6) | 60 (6) | 20&170[b](6) |
| | Filler area, E-line | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (6) | 5 (6) | 60 (6) | 20&170[b](6) |
| | | | | | | | |
| | *4. Chamber (raisins)* | | | | | | |
| | Fumigators | 1.5/1,000 $ft^3$(4) | 1.5 (6)[c] | 1.5-1 (6) | 6 (6) | 63 (6) | 150 (6) |

Table 12 (cont. 3). Frequency and duration of acute and non-acute exposures for workers and residents.

| | | Adjustment rate | Hours/workday (ref.) | | Workdays (ref.) | | |
|---|---|---|---|---|---|---|---|
| Number | Work task | (lb. MB/A) (ref) | Acute | Subc-chronic* | /7 days | /90 days | /365 days |
| | Aerators | 1.5/1,000 $ft^3$(4) | 1.5 (6)[c] | 1.5-1 (6) | 6 (6) | 63 (6) | 150 (6) |
| | Forklift drivers | 1.5/1,000 $ft^3$(4) | 1 (6) | 1-0.4 (6) | 6 (6) | 63 (6) | 150 (6) |
| | Hopper operators | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 6 (6) | 63 (6) | 150 (6) |
| | Stem picker | 1.5/1,000 $ft^3$(4) | 8 (6) | 8-8 (6) | 6 (6) | 63 (6) | 150 (6) |
| | Fumigation area, cage | 1.5/1,000 $ft^3$(4) | 1.5 (8) | 1.5-1 (8) | 6 (8) | 63 (8) | 150 (6) |
| | Leak check | 1.5/1,000 $ft^3$(4) | 0.5 (8) | n/a-n/a (8) | n/a (8) | n/a (8) | n/a (8) |
| | Aeration chambers | 1.5/1,000 $ft^3$(4) | 1.5 (6)[c] | 1.5-1 (6) | 6 (6) | 63 (6) | 150 (6) |
| | Clearing chamber | 1.5/1,000 $ft^3$(4) | 1.5 (8)[c] | 1.5-1 (8) | 6 (8) | 63 (8) | 150 (8) |
| | Hopper area | 1.5/1,000 $ft^3$(4) | 8 (8) | 8-8 (8) | 6 (8) | 63 (8) | 150 (8) |
| | | | | | | | |
| | *5. Fumigation of non-certified chambers (nuts)* | | | | | | |
| | Fumigators | 3.5/1,000 $ft^3$(4) | 5.5 (6) | 4-2.5 (6) | 6 (6) | 70 (6) | 185 (6) |
| | Cleaning fumigator | 3.5/1,000 $ft^3$(4) | 5.5 (8) | 4-2.5 (8) | 6 (8) | 70 (8) | 185 (8) |
| | Cracking, sorting, cleaning, packing | 3.5/1,000 $ft^3$(4) | 8 (6) | 8-n/a (6) | 6 (6) | 70 (6) | n/a (6) |
| | Bulk casing worker | 3.5/1,000 $ft^3$(4) | 8 (8) | 8-n/a (8) | 6 (8) | 70 (8) | n/a (8) |
| | Hopper operator | 3.5/1,000 $ft^3$(4) | 8 (8) | 8-n/a (8) | 6 (8) | 70 (8) | n/a (8) |
| | Area sampling: Fumigatorium | 3.5/1,000 $ft^3$(4) | 5.5 (8) | 4-2.5 (8) | 6 (8) | 70 (8) | 185 (8) |
| | Area sampling: Sorting, cracking, | 3.5/1,000 $ft^3$(4) | 8 (8) | 8-n/a (8) | 6 (8) | 70 (8) | n/a (8) |
| | Vacuum chamber area | 3.5/1,000 $ft^3$(4) | 8 (8) | 8-n/a (8) | 6 (8) | 70 (8) | n/a (8) |
| | Cleaning building fumigator | 3.5/1,000 $ft^3$(4) | 4 (8) | 4-2.5 (8) | 6 (8) | 70 (8) | 185 (8) |
| | | | | | | | |
| | *6. Sea van aeration* | | | | | | |
| | Upwind and downwind areas | 3.5/1,000 $ft^3$(4) | 0.5 (8) | 0.5-n/a (8) | 6 (8) | 70 (8) | n/a (8) |
| | | | | | | | |
| 5 | *Fumigation of cherries for export (T.30)* | | | | | | |
| | Control room: Start-up | 5/1,000 $ft^3$(4) | 1 (6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | Control room: Left overnight | 5/1,000 $ft^3$(4) | 1 (6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | Fumigators | 5/1,000 $ft^3$(4) | 1 (6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | Closing-up, opening-up | 5/1,000 $ft^3$(4) | 1 (6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | Forklift drivers | 5/1,000 $ft^3$(4) | 0.75 (6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | Sorters | 5/1,000 $ft^3$(4) | 8 6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | Dump station | 5/1,000 $ft^3$(4) | 8 (6) | n/a-n/a (6) | 5 (6) | n/a (6) | n/a (6) |
| | | | | | | | |
| 6 | *Fumigation at a walnut processing facility (T.31*) | Study rate-not known | | | | | |
| | Meats pool, bulk packaging, cleaning plant, cracking | no adjustment | 8 (6) | 8-n/a (6) | 6 (6) | 75 (6) | n/a (6) |
| | Warehouse workers (storage area) | no adjustment | 8 (6) | 8-8 (6) | 6 (6) | 75 (6) | 180 (6) |
| | Warehouse aisle | no adjustment | 8 (6) | 8-n/a (6) | 6 (6) | 75 (6) | n/a (6) |

Table 12 (cont. 4). Frequency and duration of acute and non-acute exposures for workers and residents.

| | | Adjustment rate | Hours/workday (ref.) | | Workdays (ref.) | | |
|---|---|---|---|---|---|---|---|
| Number | Work task | (lb. MB/A) (ref) | Acute | Subc-chronic* | /7 days | /90 days | /365 days |
| | Sorting line | no adjustment | 8 (6) | 8-n/a (6) | 6 (6) | 75 (6) | n/a (6) |
| | Fumigatorium | no adjustment | 5.5 (6) | 4-2.5 (6) | 6 (6) | 75 (6) | 180 (6) |
| | Cleaning plant | no adjustment | 8 (6) | 8-n/a (6) | 6 (6) | 75 (6) | n/a (6) |
| | Vacuum chamber | no adjustment | 8 (6) | 8-n/a (6) | 6 (6) | 75 (6) | n/a (6) |
| | Non-work areas (vicinity of fumigation chambers, fence line, alleyway, lamp posts, etc.) | no adjustment | 0.5 (8) | n/a-n/a (8) | 2 (8) | n/a (8) | n/a (8) |
| | *Compliance monitoring study*: | | | | | | |
| | Foreman's desk top | Study rate-not known | 8 | 8-8 (8) | 6 (8) | 75 (8) | 180 (8) |
| | Foreman's desk, phone box shelf | no adjustment | 8 | 8-8 (8) | 6 (8) | 75 (8) | 180 (8) |
| | Fence between chambers | no adjustment | 0.5 | n/a-n/a (8) | 6 (8) | 75 (8) | 180 (8) |
| | | | | | | | |
| 7 | *Warehouse fumigation at a brewery facility (T.32)* | Study rate-not known | | | | | |
| | Applicators (structural PCOs) | no adjustment | 1.1(study) | n/a-n/a (8) | 2 (8) | n/a (8) | n/a (8) |
| | Aerators (structural PCOs) | no adjustment | 0.6 (study) | n/a-n/a (8) | 2 (8) | n/a (8) | n/a (8) |
| | Work areas (workers in fumigated building) | no adjustment | 8 (6) | 8-n/a (8) | 3 (8) | n/a (8) | n/a (8) |
| | | | | | | | |
| 8 | *Houses (at the former Mather Air force Base) (T.33-34)* | | | | | | |
| | *a) During fumigation* | | | | | | |
| | Indoor air (neighboring house) | 3/1,000 $ft^3$ (9) | 24 | n/a-n/a (8) | 7 (8) | n/a-n/a (8) | n/a-n/a (8) |
| | Outdoor air | 3/1,000 $ft^3$ (9) | 24 | n/a-n/a (8) | 7 (8) | n/a-n/a (8) | n/a-n/a (8) |
| | *b) During aeration* | | | | | | |
| | Indoor air (neighboring house) | 3/1,000 $ft^3$ (9) | 24 | n/a-n/a (8) | n/a (8) | n/a-n/a (8) | n/a-n/a (8) |
| | Outdoor air | 3/1,000 $ft^3$ (9) | 24 | n/a-n/a (8) | n/a (8) | n/a-n/a (8) | n/a-n/a (8) |
| | | | | | | | |
| 9 | *Exposure of residents to MB in fumigated houses (T.37)* | | | | | | |
| | Southern California | 1.5/1,000 $ft^3$ (9) | 24 | n/a-n/a (8) | 7 (8) | n/a-n/a (8) | n/a-n/a (8) |
| | Northern California | 3/1,000 $ft^3$ (9) | 24 | n/a-n/a (8) | 7 (8) | n/a-n/a (8) | n/a-n/a (8) |
| | | | | | | | |
| 10 | *Exposure of residents to MB during commodity fumigation (T.38)* | | | | | | |
| | Low range of exposure days | no adjustment | 24 | 24-n/a (8) | 3 (6) | 30 (6) | 150 (6) |
| | High range of exposure days | no adjustment | 24 | 24-n/a (8) | 6 (6) | 75 (6) | 185 (6) |

References for those indicated under "Hours/workday" and "Workdays" in this table.


1. Methyl bromide proposed or suggested soil injection fumigation permit conditions (issued between 6/94 to 7/97).
2. Suggested permit conditions for methyl bromide soil fumigation within a greenhouse (issued between 9/94 to 9/96).
3. Suggested permit conditions for methyl bromide fumigation of tarped potting soil (issued between 12/95 to 9/96).
4. Based on MB product labels.
5. Based on Gibbons, 1994.
6. Based on Haskell, 1998a.
7. Based on Haskell, 1998b.

8. Assumed exposure times were based on Haskell (1998a, 1998b) or Gibbons (1994) for similarity in work practices. Only acute and subacute exposures were assumed for exposure in non-work areas, such as fence line, lamp post, alleyway.
9. Sansone, 1998.
(study) = from the study conducted by Gibbons, 1994.

Notes:
[a] average value from three large commodity fumigation facilities.
[b] each average value represents three small chambers (30, 20, and 20 days/year) and three large chambers (90, 200, and 220 days/year) for commodity fumigation facilities. The higher value was used for the estimation of MB exposure in this document.
[c] if a worker performs dual work tasks, e.g., as an applicator and an aerator, one-half of exposure of applicator and aerator were combined to represent the exposure of an applicator/aerator. The same principle was also used for other dual work tasks.

## Appendix B
## Worker Exposure Studies

Methyl bromide studies conducted in and after 1992
Daily acute, subchronic and chronic exposures for each of the following studies were calculated based upon appropriate MB air concentrations and daily duration of exposure for acute, subchronic and chronic exposures as shown in Appendix A. These exposure estimates and frequency of exposure (Appendix A) were used to calculate subacute, subchronic, and chronic exposures, which are shown in Table 11.

1. Preplant soil injection fumigation (including aeration, tarp removal)
Worker exposure studies during preplant soil injection fumigation with MB were conducted in treated fields, nurseries or greenhouses. The soil was typically prepared and was ready for planting crops. The tarpaulin was either used or not used depending on methods of fumigation. Information regarding fumigation methods are provided below.

1.a Shallow-shank tarp method for MB fumigation: Worker exposure (Siemer & Associates, 1992a)

Report No. SM924096A-D (Final report)
Study director: S.R. Siemer, Ph.D. (Siemer & Associates, Inc.)
Compliance with GLP standards (40 CFR Part 160): This study was not conducted in compliance with GLP.

Application information
Formulation: MB 99.5%, Tricon 67-33, Tricon 57-43, Tricon 80-20
Application rate: 214-398 Lbs a.i./A
Date of application: July 14, 1992 to August 6, 1992
Location (area treated, acres): Hayward (12), Wasco (78, 78, 18.76), Salinas (20, 20), Union City (10-13, 10-13), Wasco (78, 78), Watsonville (17-20, 17-20, 17-20, 9-10).
Crops to be planted: Strawberries, roses, gladiolus
Use of tarpaulin: Dow or Cadillac high barrier tarpaulin

Application method:
MB was injected into the soil using two types of application equipment. A tractor was equipped with a pair of Noble Plow shanks (horizontal V-shaped blades) which were used to inject MB at a depth of 10-12". The Noble Plows were mounted to the tool bar. The injection spacing was 12" between injection outlets, which were evenly spaced across the trailing edge of each Noble Plow blade. The effective swath width was 7 feet. Each end of the tool bar had a conventional vertical shank that was injecting MB into the soil. This tractor was also equipped with an overhead fan above the head of the applicator. The fan chamber was 17" in diameter by 21" in height and was attached to the canopy of the tractor directly over the seat of the applicator. The fan was approximately 11 feet above the ground. There was a pair of plastic air supply pipe ducts for co-pilot positioned to either side of applicator. In addition, there was an opening and closing shovel on the field side of the tool bar to open and close the soil over the leading edge of the plastic tarp.

The thickness of the plastic tarpaulin used to seal the MB in the soil was 1.0 mil (Dow HB, Cadillac HB or Armin). The end of the tarp was buried with soil at the beginning and ending of swath. The lapping edge of the tarp was continuously glued to the previously laid adjacent strip. The other side was covered with a continuous band of soil.

MB air monitoring study

Work activities (monitoring time, replicates):

1. Applicator (tractor driver of application rig) (5.08-7.38 hrs, n=8)
2. Co-pilot (applicator assistant) (5.35-7.37 hrs, n=7)
3. Shovelman (assist in turning rig around at the end of row and sealing of row end and start of next) (4.1-7.08 hrs, n=9)
4. Tarp removers (5-6 days post-fumigation; tarp was cut using an ATV equipped with a cutting wheel; exposure was monitored for supervisor, tarp cutter, roper, truck loader) (1.83-1.93 hrs, n=3)

Exposure monitoring equipment:

1. Sample collection tubes-400/200 mg petroleum charcoal (A and B tubes, SKC #226-38-02).
2. Personal air sampling pumps-SKC model #222-3 or 224-PCXR7. The flow rate was set at approximately 20 mL/min.
3. Air inlet of tube A was set at about 8 inches from the worker's mouth.
4. Sampling tubes were kept on dry ice during storage and transportation.

Recovery study: An average recovery was 69%.

Exposure assessment

Air concentrations of MB in submitted reports were pre-adjusted using an average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were adjusted for an application rate of 400 Lbs a.i./acre. One-half (10 ppb) of the MDL was used for any values reported as none detected. MB concentrations obtained from the use of conventional (vertical) shanks in soil fumigation were not used to estimate worker exposures because this soil injection method is not allowed under the current permit conditions. Results are shown in Tables 13-17. Acute and non-acute exposure estimates are shown in Table 11.

Table 13. Exposure of applicators to methyl bromide during shallow shank-tarped soil injection fumigation (1.a).

| Test No. | Lbs MB /A | Hours monitored | MB conc. ppm, v/v | Adjusted MB conc. ppm, v/v* | 24-hour TWA (ppb) Noble Plow shanks ** | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.*** | Chr.*** |
| 924096A-1 | 398 | 5.32 | 0.903 | 1.25 | 303 | 303 | n/a |
| 924096A-3 | 398 | 5.4 | 0.010 | 0.01 | 3 | 3 | n/a |
| 924096A-4 | 398 | 6.5 | 0.423 | 0.59 | 142 | 142 | n/a |
| 924096A-5 | 235 | 5.08 | 0.052 | 0.12 | 30 | 30 | n/a |
| 924096A-7 | 398 | 5.8 | 0.251 | 0.35 | 84 | 84 | n/a |
| 924096A-9 | 398 | 5.43 | 0.245 | 0.34 | 82 | 82 | n/a |
| 924096A-11 | 214 | 7.38 | 0.087 | 0.22 | 54 | 54 | n/a |
| 924096A-13 | 280 | 5.92 | 0.397 | 0.78 | 189 | 189 | n/a |
| | | | | AVERAGE | 111 | 111 | n/a |
| | | | | STDEV | 98 | 98 | n/a |

Lbs MB/A = Lbs a.i./A

*adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.01 ppm) was used for non-detects.

**with a fan operating over the applicator's head; a reduced number of conventional shanks; the system consisted of a pair of horizontal V-shaped blades (Noble Plow shanks); injection depth was 10-12"; had opening and closing shovels to open and close soil over the leading edge of the plastic tarpaulin.

***subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures (Table 11); hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

Table 14. Exposure of co-pilots to methyl bromide during shallow shank-tarped soil injection fumigation (1.a).

| Test No. | Lbs MB /A | Hours monitored | MB conc. ppm, v/v | Adjusted MB conc. ppm, v/v* | 24-hour TWA (ppb) Noble Plow shanks** | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.*** | Chr.*** |
| 924096A-1 | 398 | 5.35 | 1.546 | 2.14 | 518 | 518 | n/a |
| 924096A-3 | 398 | 5.4 | 0.102 | 0.14 | 34 | 34 | n/a |
| 924096A-4 | 398 | 6.5 | 0.792 | 1.10 | 265 | 265 | n/a |
| 924096A-5 | 235 | 6.05 | 0.220 | 0.52 | 125 | 125 | n/a |
| 924096A-7 | 398 | 5.77 | 0.772 | 1.07 | 259 | 259 | n/a |
| 924096A-9 | 398 | 5.43 | 0.559 | 0.78 | 187 | 187 | n/a |
| 924096A-11 | 214 | 7.37 | 0.285 | 0.74 | 178 | 178 | n/a |
| | | | | AVERAGE | 224 | 224 | n/a |
| | | | | STDEV | 152 | 152 | n/a |

*adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.01 ppm) was used for non-detects.

**with a fan operating over the co-pilot's head.

***subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures (Table 11); hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

Table 15. Exposure of shovelmen to methyl bromide during shallow shank-tarped soil fumigation (1.a).

| Test No. | Lbs MB /A | Hours monitored | MB conc. ppm, v/v | Adjusted MB conc. ppm, v/v* | 24-hour TWA (ppb) Noble Plow shanks | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.** | Chr.** |
| 924096A-1 | 398 | 5.47 | 0.459 | 0.64 | 154 | n/a | n/a |
| 924096A-1 | 398 | 5.3 | 0.490 | 0.68 | 164 | n/a | n/a |
| 924096A-4 | 398 | 5.77 | 0.337 | 0.47 | 113 | n/a | n/a |
| 924096A-4 | 398 | 5.83 | 0.201 | 0.28 | 67 | n/a | n/a |
| 924096A-5 | 235 | 5.6 | 0.184 | 0.43 | 104 | n/a | n/a |
| 924096A-7 | 398 | 4.1 | 0.366 | 0.51 | 123 | n/a | n/a |
| 924096A-9 | 398 | 5.02 | 1.536 | 2.13 | 515 | n/a | n/a |
| 924096A-11 | 373 | 7.08 | 0.146 | 0.22 | 52 | n/a | n/a |
| 924096A-13 | 280 | 4.53 | 0.252 | 0.50 | 120 | n/a | n/a |
| 924096A-13 | 280 | 4.47 | 0.122 | 0.24 | 58 | n/a | n/a |
| | | | | AVERAGE | 147 | n/a | n/a |
| | | | | STDEV | 135 | n/a | n/a |

*adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.01 ppm) was used for non-detects.

**subchr. (subchronic) and chr. (chronic) are used for the calculation of subchronic and chronic exposures (Table 11); hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

chronic exposures (Table 11); hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

Table 16. Exposure of tarpaulin removers employed by PCOs to methyl bromide during collection oftarp from shallow shank-tarped soil injection fumigation (1.a).

| Test No. | Lbs MB /A | Hours monitored | MB conc. ppm, v/v | Adjusted MB conc. ppm, v/v* | 24-hour TWA (ppb) Conventional shanks | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.** | Chr.** |
| 924096A-1 | 398 | 1.93 | 2.006 | 2.78 | 696 | 696 | n/a |
| 924096A-1 | 398 | 1.87 | 2.921 | 4.05 | 1013 | 1013 | n/a |
| 924096A-1 | 398 | 1.83 | 0.010 | 0.01 | 3 | 3 | n/a |
| 924096A-1 | 398 | 1.8 | 2.321 | 3.22 | 805 | 805 | n/a |
| 924096A-1 | 398 | 0.63 | 4.785 | 6.64 | 1659 | 1659 | n/a |
| | | | | AVERAGE | 835 | 835 | n/a |
| | | | | STDEV | 596 | 596 | n/a |

*adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.01 ppm) was used for non-detects.

Table 17. Exposure of tarpaulin removers employed by growers to methyl bromide during collection of tarp from shallow shank-tarped soil injection fumigation (1.a).

| Test No. | Lbs a.i. /A | Hours monitored | MB conc. ppm, v/v | Adjusted MB conc. ppm, v/v* | 24-hour TWA (ppb) Conventional shanks Acute | Subchr.** | Chr.** |
|---|---|---|---|---|---|---|---|
| 924096A-1 | 398 | 1.93 | 2.006 | 2.78 | 232 | n/a | n/a |
| 924096A-1 | 398 | 1.87 | 2.921 | 4.05 | 338 | n/a | n/a |
| 924096A-1 | 398 | 1.83 | 0.010 | 0.01 | 1 | n/a | n/a |
| 924096A-1 | 398 | 1.8 | 2.321 | 3.22 | 268 | n/a | n/a |
| 924096A-1 | 398 | 0.63 | 4.785 | 6.64 | 553 | n/a | n/a |
| | | | | AVERAGE | 278 | n/a | n/a |
| | | | | STDEV | 199 | n/a | n/a |

*adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

1.b Non-tarp deep injection for measurement of MB exposure to the applicator, applicator assistant and cultipacker tractor driver (Siemer & Associates, 1992b).

Report No. SM924096B (interim report)
Study Director: S. R. Siemer (Siemer & Associates, Inc.)
Compliance with GLP standards: There was no GLP compliance statement in the report, but it was mentioned in the protocol that the study would be conducted in compliance with GLP.
Application information
Formulation: MB 99.5%
Application rate: 398 Lbs a.i./A
Date of application: (1992): July 15 (Chowchilla), July 28 (Shafter), October 21 (Shafter)
Location (area treated, acres): Chowchilla (25), Shafter (15), Shafter (15.2)
Use of tarpaulin: No
Crop to be planted: Almond
Application method: An application tractor was equipped with mounted tool bar. Shank injectors were set 20-24" deep, spaced up to 66" apart with a wing welded to the shank to break up the chisel chimney. The application tractor was followed by a disc-cultipacker to compact seal the soil surface. The tractor was equipped with a fan over an applicator's head.

MB air monitoring study
Work tasks (monitoring time, replicates): Applicators (4.71-7.88 hrs, n=3), co-pilot (4.72, n=1), cultipacker tractor drivers (4.6-6.52, n=2).
Exposure monitoring equipment: Similar to those for shallow shank tarp fumigation.
Recovery study: An average recovery was 69%.

Exposure/data assessment
Air concentrations of MB in submitted reports were pre-adjusted using an average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50%

(Biermann and Barry, 1999; Helliker, 1999). MB concentrations were adjusted for an application rate of 400 Lbs a.i./acre. One-half of the MDL (10 ppb) was used for any values reported as none detected. Results are shown in Table 18. Acute and non-acute exposure estimates are shown in Table 11.

Table 18. Exposure of applicators, applicator assistants and cultipacker tractor drivers to methyl bromide during deep shank injection (1.b).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc. ppm, v/v** | 24-hr TWA (ppb) Acute | Subchronic*** | Chronic*** |
|---|---|---|---|---|---|---|---|
| Conventional deep shank injection (the tractor was equipped with a fan over an applicator's head) | | | | | | | |
| Applicator 1 | 398 | 4.72 | 0.377 | 0.52 | 126 | 126 | n/a |
| Applicator 2 | 398 | 7.88 | 0.539 | 0.75 | 181 | 181 | n/a |
| | | | | Average | 154 | 154 | n/a |
| Co-pilot | 398 | 4.72 | 0.146 | 0.20 | 49 | 49 | n/a |
| Cultipacker 1 | 398 | 4.6 | 0.294 | 0.41 | 99 | n/a | n/a |
| Improved deep shank injection (the tractor was equipped with a fan over an applicator's head; used scrapers and press wheels on an application rig and the disc and drag bar on the second tractor pulling a cultipacker) | | | | | | | |
| Applicator 3 | 398 | 7.25 | 0.170 | 0.24 | 57 | 57 | n/a |
| Cultipacker 2 | 398 | 6.52 | 0.210 | 0.29 | 70 | n/a | n/a |

* adjusted by the study director for an average recovery of 69%.
** adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.01 ppm) was used for non-detects.
*** subchronic and chronic were used for the calculation of subchronic and chronic exposures (Table 11); hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

1.c Exposure of workers to MB during a deep shank, non-tarp soil fumigation near Traver, Hanford, and Madera in California (Siemer & Associates, 1993a).
Report No.: SR934100.1A1 (April 16, 1993, interim report)
Study Director: S. R. Siemer (Siemer & Associates, Inc.)
Compliance with GLP standards: No detailed statement of GLP compliance
Application information
Formulation: 99% MB
Application rate: 396 Lbs a.i./A
Date of application: February 16, 1993
Location (area treated): Traver, Hanford, and Madera in California
Use of tarpaulin: No.
Crops to be planted: Not specified
Application method (Basic equipment): An application tractor equipped with three forward curved shanks with 2x width of shank thickness chisel points (60" spacing) to inject MB to a depth of approximately 24 inches. The fumigation tractor was equipped with closing scrapers behind each of the three shanks, but not equipped with an overhead fan above the applicator.

The application tractor was equipped with a Type 2 air conditioned enclosed cab. Specific equipment used at each location is as follows:

a) near Traver - used basic equipment plus a second tractor with a disc that followed the application tractor.
b) near Hanford - used basic equipment plus a second tractor pulling a cultipacker that followed the application tractor.
c) near Madera - used basic equipment plus a second tractor pulling a cultipacker that followed the application tractor.

MB air monitoring study

Work tasks (monitoring time, replicates): Applicator (2.72-6.53 hrs, n=3), disc driver (2.95 hrs, n=1), supervisor (3.28 hrs, n=1), cultipacker driver (2.95-6.2 hrs, n=2)

Exposure monitoring study: The exposure of workers to MB was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes during work activities.

Recovery: The average recovery was 69%.

Exposure/data assessment

MB concentrations were adjusted for an application rate of 400 Lbs a.i./acre and a recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (10 ppb) was used for any values indicated non-detects. Results are shown in Table 19. Acute and non-acute exposure estimates are shown in Table 11.

Table 19. Methyl bromide air concentrations near the workers' breathing zone and the estimation of worker exposure (non-tarp soil fumigation near Traver, Hanford and Madera in California (1.c).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc. ppm, v/v** | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| Traver: Basic injection equipment plus a second tractor with a disc | | | | | | | |
| Applicator 1 | 396 | 2.72 | 0.26 | 0.36 | 88 | 88 | n/a |
| Disc driver | 396 | 2.95 | 1.52 | 2.12 | 512 | 512 | n/a |
| Hanford and Madera: Basic injection equipment plus a second tractor pulling a cultipacker | | | | | | | |
| Applicator 2 | 396 | 3.4 | 0.491 | 0.68 | 165 | 165 | n/a |
| Applicator 3 | 396 | 6.53 | 0.066 | 0.09 | 22 | 22 | n/a |
| | | | | Average | 94 | 94 | n/a |
| Supervisor | 396 | 3.28 | 0.198 | 0.28 | 67 | 67 | n/a |
| Cultipacker 1 | 396 | 2.95 | 0.173 | 0.24 | 58 | n/a | n/a |
| Cultipacker 2 | 396 | 6.2 | 0.03 | 0.04 | 10 | n/a | n/a |
| | | | | Average | 34 | n/a | n/a |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.10-0.15 ug/mL) was used for non-detects.

*** subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

1.d Deep shank, non-tarp fumigation: Mitigation of MB worker exposure (near Helm, California) (Siemer and Associates, 1993b).

Report No.: SM934104.1-2, SM934104.2-1 (interim)
Study Director: S. R. Siemer (Siemer & Associates, Inc.)
Compliance with GLP standards: Not in compliance with GLP standards

Application information
Formulation: 97.6% MB/2.4% chloropicrin
Application rate: 392 Lbs a.i./A
Date of application: March 8, 1993.
Location (area treated, acres): Near Helm, California (40)
Use of tarpaulin: No.
Crop to be planted: Grapes
Application method: An application tractor was equipped with four forward curved shanks, each having a chisel point 2x wider than the width of the shank and an injector port forward of the leading edge of the shank body, behind the chisel point. The shanks were spaced 40 inches apart. The application tractor was equipped with a Type 2 air conditioned enclosed cab. Injection depth was approximately 27 inches. The shanks were each equipped with closing scrapers and followed by a gauge roller and a rolling cultipacker. During the fumigation, shank slices were covered with soil from the use of closing scrapers. The soil was then compressed by the gauge roller. The soil in shank slices was further compressed by a cultipacker which followed the application tractor within 5 minutes. In this improved deep soil injection fumigation method, a fan overhead of the applicator was not used.

MB air monitoring study
Work tasks (monitoring time, replicates): Applicator (9.18 hrs, n=1, cultipacker driver (8.38 hrs, n=1)
Exposure monitoring study: The exposure of workers to MB was measured by collecting air samples from the workers' breathing zone (approximately 8 inches from the mouth) using charcoal sampling tubes (400/200 mg charcoal) during work activities.
Recovery: The average recovery was 69%.

Exposure/data assessment
Air concentrations of MB in submitted reports were pre-adjusted using a recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were adjusted for an application rate of 400 Lbs a.i./acre. Results are shown in Table 20. Acute and non-acute exposure estimates are shown in Table 11.

Table 20. Methyl bromide air concentrations near the workers' breathing zone and the estimation of worker exposure (deep shank non-tarp soil fumigation near Helm, California) (1.d).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc. ppm, v/v** | 24-hr TWA (ppb) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.*** | Chr.*** |
| Applicator | 392 | 9.18 | 0.02 | 0.03 | 7 | 7 | n/a |
| Cultipacker | 392 | 8.38 | 0.02 | 0.03 | 7 | n/a | n/a |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (0.10-0.15 ug/mL) was used for non-detects.

*** subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

1.e Shallow shank, tarped-bed soil fumigation: Worker exposure (Siemer & Associates, 1992c).
Report No. (status): SM924096 C, M (Interim report)
Study Director: S. R. Siemer & Associates, Inc.
Compliance with GLP standards: There was no information on GLP compliance.

Application information
Formulation: 75% MB
Application rate: 187.5 Lbs a.i./A
Date of application: 10/92 and 11/17-18/92
Location (area treated, acres): Santa Maria
Use of tarpaulin: Yes
Crop to be planted: Strawberries

Application methods:

An application rig was equipped with three 6- to 8-inch shanks, closing rollers, and tarp-laying equipment plus scrapers (closing shoes) mounted between the trailing edge of each shank and the closing roller. The scrapers were mounted to be rigid laterally and pivot vertically; their leading edge was forward of the trailing edge of each shank. The scrapers kept soil heaped on the base of each shank and traveled just under the soil surface so that soil and trash flowed over them. Soil injection was 6-8 inches below bed top.

MB air monitoring study
Work tasks (monitoring time, replicates): Applicator (6.07-7.83 hrs, n=6), co-pilot (6.05-7.7 hrs, n=8), shovelman (7.1 hrs, n=2).
Exposure monitoring equipment: The exposure of workers to MB was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes (400/200 mg charcoal) during work activities.
Recovery study: An average recovery was 69%.

Exposure assessment

Air concentrations of MB in submitted study reports were adjusted using a recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 250 Lbs a.i./acre. Results are shown in Table 21. Acute and non-acute exposure estimates are shown in Table 11.

Table 21. Exposure of workers to methyl bromide during fumigation using conventional and modified injection shanks (1.e).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc. ppm, v/v** | Adjusted MB conc. (ppb) Mean | SD*** | 95th |
|---|---|---|---|---|---|---|---|
| Conventional injection shanks plus the raised co-pilot platform and an injection depth of 8" | | | | | | | |
| Applicator | 187.5 | 7.33 | 0.18 | 0.33 | 330 | 330 | 872.85 |
| Co-pilot | 187.5 | 7.3 | 0.25 | 0.46 | | | |
| Co-pilot | 187.5 | 7.25 | 0.22 | 0.40 | Range = 400-460 | | |
| Conventional injection shanks plus closing shoes | | | | | | | |
| Applicator | 187.5 | 6.07 | 0.10 | 0.18 | 180 | 180 | 476.1 |
| Co-pilot** | 187.5 | 6.22 | 0.47 | 0.86 | | | |
| Co-pilot** | 187.5 | 6.05 | 0.28 | 0.52 | Range = 520-860 | | |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 250 lbs MB/A (soil injection fumigation permit conditions, 12/95) and 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

*** If there is one data point, SD was assumed to be equalled to that data point for the purpose of calculating the 95th percentile

(TCXL/MB/Dennis21-25)

1.f Tarped-bed fumigation: Mitigation of MB worker exposure (Siemer & Associates, 1993c)

Report No. (status): SM934104.1M (interim report)

Study Director: S. R. Siemer (Siemer & Associates, Inc.)

Compliance with GLP standards: There was no information on GLP compliance.

Application information

Formulation: 75% MB/25% chloropicrin (Tri-Con 75/25)

Application rate: 262.5 Lbs a.i./A

Date of application: February 15, 1993

Location (area treated, acres): Arvin, Kern County, CA (≅ 20 acres)

Use of tarpaulin: 1.5 mil black mulch film

Crop to be planted: Peppers

Application method: MB was applied by a two-stage method. One tractor, Kennco Combi Superbedder, was equipped with swept back shanks spaced approximately 10" apart. This Supperbedder formed three beds (height-10," width-36") and injected MB to finished beds

from outlets at the end of each shank at a depth of 10-14". The shanks were positioned so that they would extend between the bed puller blades, just ahead of the bed shaper, with soil covering them to a depth of 18 to 24" during bed formation. The finished bed injection depth was approximately 12-14". Drip tape was laid from the fumigation tractor. The 6 foot wide plastic tarp was carried on a bar on the second tractor. The plastic tarp was unrolled and covered the beds. Press wheels held the tarp in place on the sides of the beds while shovels threw soil over the edge of the plastic.

MB air monitoring study

Work tasks (monitoring time, replicates): a) fumigation tractor-driver (7.77 hrs, n=1), applicator (7.72 hrs, n=1), tape layer (7.17 hrs, n=1); b) tarp laying tractor-driver (7.73 hrs, n=1), co-pilot (7.5 hrs, n=2)

Exposure monitoring equipment: The exposure of workers to MB was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes (400/200 mg charcoal) during work activities.

Recovery: A recovery of 88% was obtained by fortifying control samples with injecting standard.

Exposure assessment

Air concentrations of MB in submitted study reports were adjusted using a recovery of 88%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 250 Lbs a.i./acre. Results are shown in Table 22. Acute and non-acute exposure estimates are shown in Table 11.

Table 22. Exposure of workers to methyl bromide during application using exposure mitigation method (1.f).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc.* ppm, v/v | Adjusted MB conc.** ppm, v/v | Adjusted MB conc. (ppb) Mean | SD*** | 95th |
|---|---|---|---|---|---|---|---|
| The tractor was equipped for methyl bromide fumigation | | | | | | | |
| Driver | 262.5 | 7.77 | 0.07 | 0.12 | 120 | 120 | 317.4 |
| Applicator | 262.5 | 7.72 | 0.11 | 0.18 | 180 | 180 | 476.1 |
| Drip tape layer | 262.5 | 7.17 | 0.16 | 0.27 | 270 | 270 | 714.15 |
| The tractor was equipped for laying tarp | | | | | | | |
| Driver | 262.5 | 7.73 | 0.01 | 0.02 | 20 | 20 | 52.9 |
| Co-pilot 1 | 262.5 | 7.5 | 0.16 | 0.27 | | | |
| Co-pilot 2 | 262.5 | 7.5 | 0.01 | 0.02 | Range = 20-270 | | |

*adjusted by the study director for an a recovery of 88%. One-half of the MDL (10 ppb) was used for non-detects.

** adjusted by DPR for an application rate of 250 lbs MB/A (soil injection fumigation permit conditions, 12/95) and 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

*** If there is one data point, SD was assumed to be equalled to that data point for the purpose of calculating the 95th percentile.

(TCXL/MB/Dennis21-25)

1.g Tarped-bed fumigation for measurement of MB exposure to the applicator, applicator assistant, shovelman, irrigation pipelayers and pipe drive positions (Siemer & Associates, 1994)

Report No. (status): SM934110 (Interim report)
Study Director: S. R. Siemer (Siemer & Associates, Inc.)
Compliance with GLP standards: This study was conducted in compliance with GLP standards (40 CFR Part 160) with some exceptions. A signed copy of the QA statement was attached to the submitted report.
Application information
Formulation: 98% MB
Application rate: 287 Lbs a.i./treated acre
Date of application: July 13, 1993
Location (area treated, acres): Santa Maria, CA, 9 acres
Use of tarpaulin: 1.75 mil tarp
Crops to be planted: Strawberries
Application method: The soil was fumigated by using a modified method of injection with swept-back shanks and a closing device for sealing off the shank slice. Three sweptback-style shanks were spaced approximately 10 inches apart. MB was injected through a series of hoses, valves and tubing to an outlet at the end of each shank. The shanks were positioned so that the injection port was extended backwards underneath the compaction roller. A closing device was situated to close the shank slice between the shank and the press roller. The injection depth was 6-8 inches. The closing device moved soil over the shank slice and the compaction roller pressed the soil into the shank slice ahead of the plastic tarpaulin simultaneously laid over the top and side of the bed. The preformed beds measured 12-14 inches high and approximately 41 inches wide. The application tractor was not equipped with an overhead fan. The irrigation and cultural practices were not described in the report because of the lack of supporting documentation.

MB air monitoring study
Work tasks (monitoring time, replicates): Applicator (10.33 hrs, n=1), applicator assistant (7.98 and 8 hrs, n=2), shovelmen (9.32 and 7.83 hrs, n=2), irrigation pipelayers (8.82, 9.32, 10.17 hrs, n=3), and pipe drive positions (each 10.58 hrs, n=3)
Exposure monitoring equipment: Air samples were collected by using a sampling train consisted of two charcoal tubes containing 400 and 200 mg of charcoal and a personal sampling pump. Air intake ends of the sampling tube was positioned approximately 8 inches from the worker's mouth. The pump flow rate was approximately 20 mL/min.
Analysis (recovery): Each sample was adjusted for "Laboratory correction."

Exposure/data assessment
Air concentrations of MB in submitted study reports were adjusted using a recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 250 Lbs a.i./acre. Results are shown in Table 23. Acute and non-acute exposure estimates are shown in Table 11.

Table 23. Exposure of handlers to methyl bromide during shallow shank, tarped-bed fumigation (1.g).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc.** ppm, v/v | Adjusted MB conc. (ppb) Mean | SD*** | 95th |
|---|---|---|---|---|---|---|---|
| Applicator | 287 | 10.33 | 0.012 | 0.01 | 10 | 10 | 26.45 |
| Co-pilot A | 287 | 7.98 | 0.108 | 0.13 | | | |
| Co-pilot B | 287 | 8.00 | 0.109 | 0.13 | Range 130-130 | | |
| Shovelman A | 287 | 9.32 | 0.002 | 0.002 | | | |
| Shovelman B | 287 | 7.83 | 0.002 | 0.002 | Range = 2-2 | | |
| Pipelayer A | 287 | 8.82 | 0.008 | 0.01 | | | |
| Pipelayer B | 287 | 9.32 | 0.015 | 0.02 | | | |
| Pipelayer C | 287 | 10.17 | 0.011 | 0.01 | 13.62 | 4.22 | 20.57 |
| Irr. pipe trac. driver | 287 | 10.58 | 3.161 | 3.80 | | | |
| Irr. pipe trac. driver | 287 | 10.58 | 2.473 | 2.97 | | | |
| Irr. pipe trac. driver | 287 | 10.58 | 0.026 | 0.03 | | | |
| Irr. pipe trac. driver | 287 | 10.58 | 0.004 | 0.005 | 1702.16 | 1973.79 | 4949.04 |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 250 lbs MB/A (soil injection fumigation permit conditions, 12/95) and 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

*** If there is one data point, SD was assumed to be equalled to that data point for the purpose of calculating the 95th percentile

(TCXL/MB/Dennis21-25)

On July 7, 1998, the Department issued a memo to county agricultural commissioners informing them that the installation of sprinkler irrigation pipe during soil fumigation is not recognized in the current suggested soil permit conditions for MB (Sanders and Andrews, 1998). Some growers would like to continue the practice because the water from the sprinkler system may help keep the tarpaulin in place in windy conditions. However, the memo mentioned that preliminary data collected early in the permit condition development showed this procedure could result in serious over exposure to workers involved in pipe installation.

1.h MB exposure to the tarpaulin cutter and remover positions from tarped-shallow broadcast fumigation (TriCal, 1993a).

Report No. (status): TC211 (interim report)
Study Director: TriCal, Inc.
Compliance with GLP standards: A signed copy of GLP statement was not available in the report.

Application information

Formulation: MB 99.5% (Burrell and Corcoran), 80% (Watsonville )

Application rate (Lbs a.i./A): 298.5 (Burrell), 398 (Corcoran), and 280 (Watsonville)

Date of application: April 4, 12, and 28, 1993

Location (area treated, acres): Burrell (10.74 acres), Corcoran (10.48 acres), Watsonville (8.07 acres)

Use of tarpaulin: Dow HB or Cadillac HB

Crops to be planted: Grapes, flowers, turf

Application method: The broadcast fumigation of MB was made with Noble Plow shanks at the depth of 10-12". The tarpaulin was left in place for a minimum of five days after the completion of fumigation. After the five-day waiting period, each tarp panel was cut by a four wheeler using a cutting coulter. The aeration period for MB after the tarp cutting was complete was one day. At the end of the aeration period, tarp removal proceeded by windrowing the plastic panels and then pulling these panels into a truck for disposal.

MB air monitoring study

Work tasks (monitoring time, replicates): Tarpaulin cutters (driver) (0.52-1.23 hrs, n=3), tarpaulin pullers or removers (e.g. tractor drivers, end rollers) (1.09-2.1 hrs, n=12).

Exposure monitoring equipment: Air samples were collected by using a sampling train consisting of two charcoal tubes containing 400 and 200 mg of charcoal and a personal sampling pump. Samples were taken from the breathing zones of the tarpaulin cutter and puller positions.

Recovery: The average recovery was 69%.

Exposure/data assessment

Air concentrations of MB in submitted study reports were adjusted using the average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 400 Lbs a.i./acre. Results are shown in Table 24. Acute and non-acute exposure estimates are shown in Table 11.

Table 24. Exposure of tarp cutters and removers to methyl bromide (1.h).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc.** ppm, v/v | Adjusted MB conc. (ppb) Mean | SD*** | 95th |
|---|---|---|---|---|---|---|---|
| (By PCOs) | | | | | | | |
| Cutter 2 | 298.5 | 0.52 | 0.01 | 0.02 | 326.22 | 537.00 | 1209.58 |
| Cutter 1 | 398 | 1.1 | 0.01 | 0.01 | | | |
| Cutter 1 | 280 | 1.23 | 0.48 | 0.95 | | | |
| (By growers) | | | | | | | |
| Assume the same acute MB concentrations as that for PCOs | | | | | 326.22 | 537.00 | 1209.58 |
| (By PCOs) | | | | | | | |
| Puller 1(a) | 298.5 | 2 | 0.01 | 0.02 | 131.03 | 366.71 | 734.26 |
| Puller 2(b) | 298.5 | 2 | 0.01 | 0.02 | | | |
| Puller 3(b) | 298.5 | 2 | 0.7 | 1.29 | | | |
| Puller 1 | 398 | 2.1 | 0.04 | 0.06 | | | |
| Puller 2 | 398 | 2.08 | 0.01 | 0.01 | | | |
| Puller 3 | 398 | 1.6 | 0.01 | 0.01 | | | |
| Puller 1 | 280 | 1.17 | 0.01 | 0.02 | | | |
| Puller 2 | 280 | 1.21 | 0.03 | 0.06 | | | |
| Puller 3 | 280 | 1.2 | 0.01 | 0.02 | | | |
| Puller 4 | 280 | 1.12 | 0.01 | 0.02 | | | |
| Puller 5 | 280 | 1.09 | 0.01 | 0.02 | | | |
| Puller 6 | 280 | 1.1 | 0.01 | 0.02 | | | |
| (By growers) | | | | | | | |
| Assume the same acute MB concentrations as that for PCOs | | | | | 131.03 | 366.71 | 734.26 |

(a) end roller (b) tractor driver

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One half of the MDL (0.01 ppm) was used for non-detects.

*** If there is one data point, SD was assumed to be equalled to that data point for the purpose of calculating the 95th percentile

(TCXL/MB/Dennis21-25)

1.i Worker exposure to MB during tarp cutting and removal (TriCal, 1993b)

Report No. (status): TC233.3 (interim)
Study Director: Kirk Fowler (TriCal, Inc.)
Compliance with GLP standards: This study was not conducted in compliance with GLP standards (40 CFR Part 160).

Application information
Formulation: 99.5% MB
Application rate: 390.2 Lbs a.i./A
Date of application: October 19, 1993
Location (area treated, acres): Gonzales (Monterey) (7.09)

Use of tarpaulin: 1.0 mil high barrier test film
Crops to be planted: Head lettuce
Application method: MB was injected into the soil at a depth of 10 inches using Noble Plow shanks. The fumigated area was thereafter covered with high barrier test film. The tarpaulin was left in place for at least five days after the complete of the application. After the five-day waiting period, each panel of the tarp was cut along the tape by an ATV equipped with a cutting wheel. After cutting and a 24-hour waiting period had elapsed, the tarpaulin was removed by workers.

MB air monitoring study

Work tasks (monitoring time, replicates): Tarp cutter (0.36 hrs, n=1), Tarp remover (Tractor driver, basketman, end puller) (1.20-1.23 hrs, n=3)
Exposure monitoring equipment: MB levels were measured by collecting air samples from the workers' breathing zone using charcoal tubes (400/200 mg charcoal) for the duration of the work period.
Recovery: The average recovery was 69%.

Exposure/data assessment

Air concentrations of MB in submitted study reports were adjusted using the average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 400 Lbs a.i./acre. Results are shown in Table 25. Acute and non-acute exposure estimates are shown in Table 11.

Table 25. Exposure of tarp cutters and removers to methyl bromide following the use of high barrier tarpaulin (1.i).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc.** ppm, v/v | Adjusted MB conc. (ppb) Mean | SD*** | 95th |
|---|---|---|---|---|---|---|---|
| Tarp cutter (by PCOs) | 390.2 | 0.36 | 0.22 | 0.31 | 310 | 310 | 819.95 |
| Tarp remover (by PCOs) | | | | | | | |
| Tarp remover 1 (Tractor driver) | 390.2 | 1.2 | 0.97 | 1.37 | 1370 | 1370 | 3623.65 |
| Tarp remover 2 (Basketman) | 390.2 | 1.21 | 0.92 | 1.30 | 1300 | 1300 | 3438.5 |
| Tarp remover 3 (End puller) | 390.2 | 1.23 | 0.02 | 0.03 | 30 | 30 | 79.35 |
| Tarp cutter (by growers) | | | | | | | |
| Assume the same acute MB concentrations as that for PCOs | | | | | 310 | 310 | 819.95 |
| Tarp remover (by PCOs) | | | | | | | |
| Assume the same acute MB concentrations as that for PCOs | | | | | | | |
| Tarp remover 1 (Tractor driver) | | | | | 1370 | 1370 | 3623.65 |
| Tarp remover 2 (Basketman) | | | | | 1300 | 1300 | 3438.5 |
| Tarp remover 3 (End puller) | | | | | 30 | 30 | 79.35 |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 400 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One half of the MDL (0.01 ppm) was used for non-detects.

*** If there is one data point, SD was assumed to be equalled to that data point for the purpose of calculating the 95th percentile

(TCXL/MB/Dennis21-25)

2. Soil fumigation in nurseries and greenhouses

2.a Worker exposure assessment from potting soil fumigation (Siemer & Associates, 1992d)

Report No. (status): SM924099B1 (interim)
Study Director (company): S. R. Siemer (Siemer and Associates, Inc.)
Compliance with GLP standards: There was no information on compliance with GLP standards (40 CFR Part 160).

Application information
Formulation: 99.5% MB
Application rate: 0.5 Lbs a.i./$yd^3$
Date of application: October 1992
Location (area treated, acres): Visalia (Tulare County) (6,000 $yd^3$)
Use of tarpaulin: 6 mil polyethylene
Crops to be planted: Ornamentals
Application method: MB was injected through two perforated plastic hoses (3/16" diameter) spaced 10 feet apart on top of the soil, stretching the length of the tarpaulin-covered potting soil pile. The tarp around the perimeter of the soil pile was sealed with "sand snakes." The typical potting soil pile was 27 feet wide x 100 feet long x 4 feet deep. The tarp was left in place for two days after the completion of the application. Two days following fumigation, the tarp was removed by hand. The soil pile was left to vent for an additional two days. A

skip loader placed approximately 2 ½ loads into a dump truck which then transported to the potting area which was approximately one half mile away. An enclosed cab front end loading tractor heaped the soil into a new pile. This same tractor was also used to fill the canning equipment hopper during the canning operation. The canning operation consisted of the soil being screw-conveyed to a revolving bin, which emptied soil into pots that were conveyed to the canning area. Two canners filled pots with soil. Other workers involved in the canning operation were one pot stager and two stackers. Only canners were monitored for exposure because they had the most immediate contact with the fumigated soil.

Air monitoring study

Work tasks (monitoring time, replicates): Applicator (0.33-0.68 hrs, n=2), applicator assistant (0.28-0.68 hrs, n=2), tarpaulin remover (0.58-1.22 hrs, n=4), tractor driver (2.02-2.4 hrs, n=2), dump truck driver (1.98-2.4 hrs, n=3), and potter or canner (2.78-3.33 hrs, n=4).

Exposure monitoring equipment: The exposure was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes (400/200 mg charcoal) connected to a personal air sampling pump.

Recovery: The average recovery was 69%.

Exposure/data assessment

Air concentrations of MB in submitted study reports were adjusted using the average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 0.6 Lbs MB/$yd^3$. Results are shown in Table 26. Acute and non-acute exposure estimates are shown in Table 11.

Table 26. Worker exposure assessment from potting soil fumigation (2.a).

| Replicate | Lbs MB /yd3 | Monitoring time (hrs) | MB conc. ppm, v/v* | Adjusted MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| Applicator 1 | 0.5 | 0.33 | 0.37 | 0.61 | 26 | n/a | n/a |
| Applicator 2 | 0.5 | 0.68 | 0.24 | 0.40 | 17 | n/a | n/a |
| | | | | Average | 21 | n/a | n/a |
| Applicator assistant 1 | 0.5 | 0.28 | 0.45 | 0.75 | 31 | n/a | n/a |
| Applicator assistant 2 | 0.5 | 0.68 | 0.02 | 0.03 | 1 | n/a | n/a |
| | | | | Average | 16 | n/a | n/a |
| Tarp remover 1 | 0.5 | 0.58 | 1.93 | 3.20 | 133 | n/a | n/a |
| Tarp remover 2 | 0.5 | 0.6 | 1.28 | 2.12 | 88 | n/a | n/a |
| Tarp remover 3 | 0.5 | 1.22 | 0.63 | 1.04 | 43 | n/a | n/a |
| Tarp remover 4 | 0.5 | 1.22 | 1.59 | 2.63 | 110 | n/a | n/a |
| | | | | Average | 94 | n/a | n/a |
| | | | | STDEV | 38 | n/a | n/a |
| Tractor driver 1 | 0.5 | 2.4 | 0.45 | 0.75 | 31 | n/a | n/a |
| Tractor driver 2 | 0.5 | 2.02 | 0.01 | 0.02 | 1 | n/a | n/a |
| | | | | Average | 16 | n/a | n/a |
| Truck driver 1 | 0.5 | 2.4 | 0.01 | 0.02 | 1 | n/a | n/a |
| Truck driver 2 | 0.5 | 2.02 | 0.01 | 0.02 | 1 | n/a | n/a |
| Truck driver 3 | 0.5 | 1.98 | 0.11 | 0.18 | 8 | n/a | n/a |
| | | | | Average | 3 | n/a | n/a |
| | | | | STDEV | 4 | n/a | n/a |
| Potter 1 | 0.5 | 3.33 | 0.01 | 0.02 | 2 | n/a | n/a |
| Potter 2 | 0.5 | 3.3 | 0.46 | 0.76 | 95 | n/a | n/a |
| Potter 3 | 0.5 | 2.8 | 0.03 | 0.05 | 6 | n/a | n/a |
| Potter 4 | 0.5 | 2.78 | 0.12 | 0.20 | 25 | n/a | n/a |
| | | | | Average | 32 | n/a | n/a |
| | | | | STDEV | 43 | n/a | n/a |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 0.6 lbs MB/yd3 and 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

*** subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

2.b Exposure of workers to MB during soil fumigation in greenhouses (Siemer & Associates, 1992e)

Report No. (status): SM924099A1 (interim)

Study Director (company): S. R. Siemer (Siemer and Associates, Inc.)

Compliance with GLP standards: There was no information to determine whether the study was conducted in compliance with GLP standards

Application information
Formulation: 99.5% MB
Application rate: 447.75 Lbs a.i./A
Date of application: August and September, 1992
Location (area treated, acres): Oxnard, Ventura County (approximately 3/4 acres)
Use of tarpaulin: One mil high density tarpaulin
Application method: Each plot of soil in a greenhouse to be treated with MB measured 20 feet wide by 150 feet in length. The applicator brought the fumigation trailer, which was used for heating the gas, to the east opening in the building. After all workers had cleared the area, the gas tank was connected to the heater coils that were heated by a propane burner. From the heater coils another hose was connected to the main PVC plastic pipe feeder. Hot MB was released through the plastic pipe manifold to which were attached a series of perforated plastic hoses. These hoses ran along the surface of the soil under preplaced tarpaulin. Current permit conditions require applicators to introduce the fumigant from outside the greenhouse. In this study, the fumigant was not introduced from outside the greenhouse.

Three days after the completion of fumigation, the tarp was cut open by hand using knives with elongated handles. The strips of the tarp were pulled apart and the greenhouse was allowed to vent for 48 hours. At the end of the venting period, the tarp was pulled and disposed.

Air monitoring study
Work tasks (monitoring time, replicates): Applicator (1.17-1.73 hrs, n=2), tarpaulin venter (0.35-0.65 hrs, n=4), tarp remover (1.03-1.37 hrs, n=4).
Exposure monitoring equipment: The exposure was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes (400/200 mg charcoal) connected to a personal air sampling pump. The flow rate was approximately 20 mL/min.
Recovery: The average recovery was 69%.

Exposure/data assessment
Air concentrations of MB in submitted study reports were adjusted using the average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 450 Lbs a.i./acre. Results are shown in Table 27. Acute and non-acute exposure estimates are shown in Table 11.

Table 27. Exposure of workers to methyl bromide during soil fumigations in greenhouses (2.b).

| Work task | Lbs MB /A | Monitoring time (hrs) | MB conc. ppm, v/v* | MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| Applicator 1 | 447.75 | 1.17 | 3.468 | 4.81 | 401 | n/a | n/a |
| Applicator 2 | 447.75 | 1.73 | 6.265 | 8.69 | 724 | n/a | n/a |
| | | | | Average | 562 | n/a | n/a |
| Tarp venter 1 | 447.75 | 0.4 | 5.766 | 8.00 | 333 | n/a | n/a |
| Tarp venter 2 | 447.75 | 0.35 | 0.229 | 0.32 | 13 | n/a | n/a |
| Tarp venter 3 | 447.75 | 0.6 | 0.01 | 0.01 | 0.6 | n/a | n/a |
| Tarp venter 4 | 447.75 | 0.65 | 0.461 | 0.64 | 26.6 | n/a | n/a |
| | | | | Average | 93 | n/a | n/a |
| | | | | STDEV | 160 | n/a | n/a |
| Tarp remover 1 | 447.75 | 1.03 | 0.038 | 0.05 | 2 | n/a | n/a |
| Tarp remover 2 | 447.75 | 1.03 | 0.017 | 0.02 | 1 | n/a | n/a |
| Tarp remover 3 | 447.75 | 1.37 | 0.004 | 0.01 | 0.2 | n/a | n/a |
| Tarp remover 4 | 447.75 | 1.32 | 0.007 | 0.01 | 0.4 | n/a | n/a |
| | | | | Average | 1 | n/a | n/a |
| | | | | STDEV | 1 | n/a | n/a |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 450 lbs MB/A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of MDL (10 ppb) was used for non-detects.

*** subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

3. MB monitoring: The Grain Product Group (Hosoda, 1992)

Report No. (status): Not assigned (revised; September 1, 1992)
Study Director (company): Ed Hosoda (Cal Ag-Industrial Supply, Inc.)
Compliance with GLP standards: There was no information to determine whether the study was conducted in compliance with GLP standards.

Application information
Formulation: Methyl Bromide 100
Application rate: 1.5-2 Lbs a.i./1,000 $ft^3$
Date of application: May to August, 1992
Locations: West Sacramento, Modesto, and Maxwell
Use of tarpaulin: 6 mil polyethylene tarpaulin, if used
Application method:

a) Fumigation applicators: MB was introduced from a cylinder into sea containers through ¼" polyethylene tubing. The application rate was 2 Lbs MB/1,000 $ft^3$. The application periods were 19.5, 21, and 34 minutes.
b) Worker at initiation of aeration of sea containers/truck trailers: The workers opened both doors of the container and placed an insect screen to exclude reentry of flying insects.

Eighteen-inch, 10,000 cfm "Patton" fans were left running for the entire aeration period of 24 hours. The monitoring periods were 3.5, 6, and 8.5 minutes.

c) Forklift drivers emptying sea containers/truck trailers: Each container had been previously aerated for approximately 24 hours, and had no detectable amount of MB when using a Draeger MB 5/b tube. A forklift operator took about 15 minutes to unload each container contents and place produce inside the warehouse. The monitoring periods were 22, 25, and 41 minutes.
d) Workers at initiation of aeration of tarpaulin fumigation: A tarp-covered stack of 1,000 $ft^3$ of blackeye beans was fumigated with 1.5 Lbs MB. The worker removed bags of beans from the outside edge of the tarps, then lifted the edges of the tarps and removed them from the entire stack. The monitoring periods were 4, 7, and 7 minutes.
e) Forklift drivers emptying non-certified fumigation chambers: Two non-certified chambers with 2,500 $ft^3$ capacities were used in this study. Each chamber held a variety of rice products, with varying types of packaging. These chambers were aerated until air concentration of MB was below 5 ppm as measured with Draeger MB 5/b tube. Then the forklift operators were allowed to enter the chamber. The monitoring periods were 17, 30, and 32.5 minutes.
f) Air monitoring in fumigated rice warehouse: After sea containers were fumigated and aerated, the product was brought back to storage in a warehouse. The product consisted of a wide variety of rice products with various types of packaging. Air samples were collected near the surface of rice bags on the pallets. Each monitoring period was 120 minutes.
g) Workers re-processing fumigated rice products: The previously fumigated rice products were re-processed. Workers opened packages and poured rice into a receptacle which transfers the product into a storage bin. A worker may be required to work a full shift performing this task. The time between the aeration of fumigated rice products and re-processing was not known. Each monitoring period was 60 minutes.

Air monitoring study

Work tasks (monitoring time, replicates): Applicators (21-34 min, n=3), workers at initiation of aeration of sea containers/truck trailers (6-8.5 min, n=3), workers at initiation of aeration of tarpaulin fumigation (4-7 min, n=3), forklift drivers emptying sea containers/truck trailers (22-41 min, n=3), forklift drivers emptying non-certified fumigation chambers (17-32.5 min, n=3), air monitoring in rice warehouse (120 min, n=2), workers handled re-processed fumigated rice (60 min, n=3).

Exposure monitoring equipment: The exposure was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes (400/200 mg charcoal) connected to a personal air sampling pump. The monitoring method followed was that recommended in "Cal/EPA, DPR Methodology for Measuring MB Exposure to Workers" (Ross and Gibbons, 1992). The two charcoal tubes can handle the maximum air volume of 11 liters.

Recovery: The average recovery was 69%.

Exposure/data assessment

Air concentrations of MB in submitted study reports were adjusted using the average recovery of 69%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50%

(Biermann and Barry, 1999; Helliker, 1999). MB concentrations were further adjusted by DPR for an application rate of 6 Lbs MB/1,000 $ft^3$. Results are shown in Tables 28. Acute and non-acute exposure estimates are shown in Table 11.

Table 28. Exposure of workers to methyl bromide during and after fumigations of grain products (3).

| Work task | Lbs MB/ 1,000 ft3 | Monitoring time (min) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| **Monitoring of fumigation applicators:** | | | | | | | |
| Applicator 1 | 2 | 19.5 | 0.797 | 3.30 | 825 | 894 | 687 |
| Applicator 2 | 2 | 21 | 0.765 | 3.17 | 792 | 858 | 660 |
| Applicator 3 | 2 | 34 | 3.227 | 13.36 | 3,340 | 3,618 | 2,783 |
| | | | | Average | 1,652 | 1,790 | 1,377 |
| | | | | STDEV | 1,462 | 1,584 | 1,218 |
| **Worker at initiation of aeration of sea containers/truck trailers** | | | | | | | |
| Aerator 1 | 2 | 6 | 1.303 | 5.39 | 1,349 | 1,461 | 1,124 |
| Aerator 2 | 2 | 3.5 | 8.028 | 33.24 | 8,309 | 9,001 | 6,924 |
| Aerator 3 | 2 | 8.5 | 8.172 | 33.83 | 8,458 | 9,163 | 7,048 |
| | | | | Average | 6,039 | 6,542 | 5,032 |
| | | | | STDEV | 4,062 | 4,401 | 3,385 |
| **Workers at initiation of aeration of tarpaulin fumigation** | | | | | | | |
| Aerator 1 | 1.5 | 4 | 0.01 | 0.06 | 14 | 15 | 12 |
| Aerator 2 | 1.5 | 7 | 0.526 | 2.90 | 726 | 786 | 605 |
| Aerator 3 | 1.5 | 7 | 0.01 | 0.06 | 14 | 15 | 12 |
| | | | | Average | 251 | 272 | 209 |
| | | | | STDEV | 411 | 445 | 343 |
| **Forklift drivers emptying sea containers/truck trailers** | | | | | | | |
| Driver 1 | 2 | 22 | 0.01 | 0.04 | 2 | 1 | 1 |
| Driver 2 | 2 | 41 | 0.25 | 1.04 | 43 | 22 | 22 |
| Driver 3 | 2 | 25 | 0.01 | 0.04 | 2 | 1 | 1 |
| | | | | Average | 16 | 8 | 8 |
| | | | | STDEV | 24 | 12 | 12 |
| **Forklift drivers emptying non-certifying fumigation chambers** | | | | | | | |
| Driver 1 | 2 | 17 | 0.041 | 0.17 | 7 | 4 | 4 |
| Driver 2 | 2 | 30 | 0.044 | 0.18 | 8 | 4 | 4 |
| Driver 3 | 2 | 32.5 | 0.025 | 0.10 | 4 | 2 | 2 |
| | | | | Average | 6 | 3 | 3 |
| | | | | STDEV | 2 | 1 | 1 |
| **Air monitoring in fumigated rice warehouse** | | | | | | | |
| Ambient air 1 | 2 | 120 | 0.04 | 0.17 | 55 | 55 | 55 |
| Ambient air 2 | 2 | 120 | 0.007 | 0.03 | 10 | 10 | 10 |
| | | | | Average | 32 | 32 | 32 |
| **Workers handled re-processing fumigated rice product** | | | | | | | |
| Worker 1 | 2 | 60 | 0.01 | 0.04 | 10 | n/a | n/a |
| Worker 2 | 2 | 60 | 0.01 | 0.04 | 10 | n/a | n/a |
| Worker 3 | 2 | 60 | 0.01 | 0.04 | 10 | n/a | n/a |
| | | | | Average | 10 | n/a | n/a |
| | | | | STDEV | 0 | n/a | n/a |

* adjusted by the study director for an average recovery of 69%.

** adjusted by DPR for an application rate of 6 lbs MB/1,000 ft3 and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of MDL (0.01 ppm) was used for non-detects.

*** subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

4. Determination of MB exposure during dried fruit and tree nut fumigation practice (Radian Corporation, 1992)

Report No. (status): RCN 256-254-04-01 (final)
Study Director (company): Radian Corporation
Compliance with GLP standards: The study was not conducted in compliance with GLP standards. There was not a signed copy of the QA statement in the submitted report.

Application information

Formulation: Not reported
Application rate: 0.8-3.0 Lbs a.i./1,000 $ft^3$
Date of application: August to October, 1992
Area treated: Sea/land containers, chambers
Use of tarpaulin: No
Application method:

1. Sea van fumigation (contained packages of dried prunes and mixed fruit): Volume of container = 2,200 $ft^3$. Application rate = 2.27 Lbs MB/1,000 $ft^3$. Hot MB was introduced into the sea van from an outside source. The fumigation time was 17 hours. The van was aerated for two hours after the completion of fumigation.

2. Chamber (contained dried prunes): Volume of chamber = 15,000 $ft^3$. Application rate = 0.8 Lbs MB /1,000 $ft^3$. Hot MB was injected into the chamber from an outside source. The fumigation time was 20 hours. The chamber was aerated for 6 hours after the completion of fumigation.

3. Big chamber fumigation (contained raisins): Volume of chamber = 143,382 $ft^3$. Application rate = 1.5 Lbs MB/1,000 $ft^3$. MB was introduced from an outside source through a hose. Distribution of MB in the chamber was assisted by big fans. The fumigation time was 24 hours. The chamber was aerated for 24 hours after the completion of fumigation.

4. Chamber (contained raisins): Volume of two chambers were 45,000 and 55,000 $ft^3$. Application rate = 1 lb MB/1,000 $ft^3$. Hot MB was injected into the chambers from an outside source. The fumigation time was 24 hours. The chambers were aerated for 24 hours after the completion of fumigation. The fumigated products were removed by forklift to the production line for processing.

5. Fumigation of vacuum chamber and two kinds of non-certified chambers (contained walnuts, shelled and in-shell): Application rate = 3 Lbs MB/1,000 $ft^3$ for fumigatorium (silo chambers in the main plant) (20 chambers of 2,600 $ft^3$ each), vacuum chambers (2 chambers of 1,400 $ft^3$ each), and cleaning plant chambers (8 chambers of 2,000 $ft^3$). The fumigation time was 2 hours for all chambers. The aeration times were 6 hours for fumigatorium chambers, 2 hours for vacuum chamber, and 30-45 minutes for cleaning plant chambers. It was noted in the submitted report that the fumigation processes were

performed constantly. Consequently, no separate sampling of aeration and clearing the chamber was possible. The data for all the fumigators represents the combined results of injection, aeration, and clearing operations.

6. Sea van aeration (contained dried unpackaged prunes): Volume of container = 2,200 $ft^3$. Application rate = 2.73 Lbs MB/1,000 $ft^3$. The fumigation time was 24 hours. The sea van was aerated for 2 hours.

Air monitoring study

Work tasks (monitoring time and replicates are shown in Table 29).

1. Sea van fumigation: Fumigator (the loading dock supervisor), fumigation observer (QA supervisor). Sampling times ranged from 19 to 25 minutes. Downwind samples were collected 15 feet away from the entry door. The collection time with respect to the fumigation process was not specified.

2. Chamber fumigation (dried prunes). Fumigator, forklift operator, area samples (1 meter from open door, 2 and 15 meters from chamber), and leak check. Sampling times ranged from 5 to 122 minutes. The area samples (1 m from open door) were collected while the prunes were removed from the chamber. Samples for 2 and 15 meters from the chamber were collected during the fumigation process. The starting time for sample collection with respect to the aeration process was not specified.

3. Big chamber fumigation (raisins): Fumigators, aerators, forklift drivers, catchall operator, hopper operators, capper dumper, inspector, moisture checker at line control, driver of forklift to side hopper, stem pickers, and areas. Sampling times ranged from 22 to 498 minutes. Area samples during the fumigation process were located on a tractor, which pulled the MB application apparatus and on a forklift, which stayed near the shed. During the aeration process, area samples (shed-604, shed-605, shed-606) were set up on each fan associated with these sheds. Exposure of workers in the processing line (forklift drivers, hopper operators, capper and catchall operators) were monitored on the night of the same aeration date. The distance of the processing line from the chambers was not specified. Area samples (capper, hopper and catchall areas) were also collected in the processing portion of the plant during the same workshift.

   Exposure of workers in the packaging portion of the plant was also monitored. The distance of the packaging area from the chambers was not specified in the submitted report. Air samples were collected one day after initiation of aeration. Area samples (hopper, stem picker, and filler (packaging) areas) were also collected in this packaging area.

4. Chamber (raisins): Fumigators, aerators, chamber worker, stem pickers, forklift driver, hopper operator, and areas. Sampling times ranged from 5 to 536 minutes. During the fumigation period, area samples were located at both sides of the chamber and attached directly to the cage. Leak check samples were collected at locations approximately 1 foot from the edge of the door. There was no information with respect to the time of collection and the distance of samples from the MB source for aeration and clearing samples.

5. Fumigation of vacuum chamber and two kinds of non-certified chambers (walnuts, shelled and in-shell): Cracking workers, sorters, fumigators, cleaning-sort workers, hopper operators, and areas. Sampling times ranged from 418 to 621 minutes. Information regarding the time of collection and the distance of samples from the source of MB for these area samples were not specified: fumigatorium, vacuum chamber, sorting area, cracking area, and cleaning building. It was assumed that the sampling locations were in the vicinity of these mentioned areas.

6. Sea van aeration: The following samples were taken after opening the doors of the sea van for aeration: upwind of sea van, downwind-left, downwind-right, downwind-center. Sampling times ranged from 15 to 119 minutes.

Exposure monitoring equipment: The exposure was measured by collecting air samples from the workers' breathing zone (20 cm radius circle from the worker's nose and mouth) and work areas using charcoal sampling tubes (400/200 mg charcoal) connected to a personal air sampling pump.

Analysis: The contents of the sampling tube was emptied into a glass headspace vial. Benzyl alcohol was added and the vial was thermostated at 110 $^{o}$C. The headspace gas was sampled and analyzed by a gas chromatograph equipped with an electron capture detector. A recovery study was not conducted.

Exposure/data assessment

Grab samples taken inside the van before aeration and from edges of van during aeration are not shown in this document. The fumigation practices for dried fruit and tree nuts during the study may not in full compliance with current permit conditions. MB concentrations in Table 29 were adjusted by DPR for an application rate of 1.5 and 3.5 Lbs MB/1,000 ft$^3$. Acute and non-acute exposure estimates are shown in Table 11.

5. MB: Measurement of exposure to the fumigators, forklift drivers, cherry sorters, and other workers (Stegmiller and Lee, 1992)

Report No. (status): Interim report
Study Director (company): Mr. Frank Stegmiller (Bioentech Incorporated)
Compliance with GLP standards: The study was not conducted in compliance with GLP standards.

Application information
Formulation: Not reported
Application rate: 3 Lbs a.i./1,000 $ft^3$
Date of application: May 23-25, 1992
Location (area treated): San Joaquin County (3 air-tight fumigation chambers measured 71,000, 46,000, and 22,000 $ft^3$). The chambers were constructed primarily of plywood and installed on concrete floors.
Use of tarpaulin: No
Application method: MB was injected into the chambers through a closed gas-tight system from a pressurized cylinder. This task was performed by DPR-certified applicators. Bulk fresh cherries were fumigated for two to three hours. After the completion of fumigation, the gas exhaust system was started and the fresh air inlets were opened to allow aeration of the treated cherries. An aeration period was not mentioned in the submitted report. The commodity was moved from the chamber when the air concentration of MB in the chamber was less than 5 ppm.

Air monitoring study
Work tasks (monitoring times and replicates are shown in Table 30).
Exposure monitoring equipment: The exposure was measured by collecting air samples from the workers' breathing zone using charcoal sampling tubes connected to a personal air sampling pump. Area samplers were placed in close proximity of the chamber, the packing, and the gas injection areas.
Analysis and recovery studies: MB was analyzed by gas chromatography following NIOSH Method 2520. Weight of MB from samples was adjusted for the laboratory recovery efficiency, but the percentage of recovery was not disclosed in the submitted report.

Exposure/data assessment
The fumigation practices for cherries during the study was not conducted in compliance with current permit conditions. The submitted study report mentioned that air concentrations of MB were adjusted for a recovery. MB concentrations in Table 30 were further adjusted by DPR for an application rate of 5 Lbs MB/1,000 $ft^3$. Acute and non-acute exposure estimates are shown in Table 11.

Compliance monitoring study conducted by WH&S

On May 30, 1996, staff from the Worker Health and Safety Branch, DPR, conducted a compliance monitoring study to determine the air concentration of MB at the same work site (Gibbons, 1996). Cherries were fumigated with MB for two hours at a rate of 3 Lbs MB/1,000 $ft^3$. The fumigated cherries on that day were mechanically aerated for five hours prior to the start of processing. The present permit conditions require a minimum aeration of four hours. Air samples were collected from five locations in the processing building. Air samples were obtained by drawing workplace air through charcoal sorbent tubes during the processing work shift. Results of this study were included in Table 30 for comparison with those obtained from a study previously performed by Bioentech Incorporated.

Table 29. Exposure of workers to MB during and after fumigation of dried fruit and tree nut products (4).

| Work task | Lbs MB /1,000 ft3 | Monit. time (min) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| **a) Sea Van:** | | | | | | | |
| Fumigator | 2.27 | 25 | 0.6 | 0.79 | 33 | n/a | n/a |
| Fumigator observer | 2.27 | 25 | 0.17 | 0.22 | 9 | n/a | n/a |
| 15-ft downwind 1 | 2.27 | 21 | 0.064 | 0.08 | 4 | n/a | n/a |
| 15-ft downwind 2 | 2.27 | 19 | 0.035 | 0.05 | 2 | n/a | n/a |
| | | | | Average | 3 | n/a | n/a |
| **b) Chamber (dried prunes):** | | | | | | | |
| Forklift operator | 0.8 | 47 | 0.0045 | 0.02 | 0.35 | n/a | n/a |
| Fumigator | 0.8 | 5 | 12 | 45.00 | 938 | n/a | n/a |
| 1 m from open door | 0.8 | 40 | 0.01 | 0.04 | 0.78 | n/a | n/a |
| 2 m from chamber | 0.8 | 120 | 1.8 | 6.75 | 141 | n/a | n/a |
| 15 m from chamber | 0.8 | 119 | 0.06 | 0.23 | 5 | n/a | n/a |
| Leak check, side seal | 0.8 | 122 | 170 | 637.50 | 13,281 | n/a | n/a |
| **c) Big chamber fumigation (raisins):** | | | | | | | |
| Primary fumigator | 1.5 | 33 | 3.2 | 6.40 | 800 | 667 | 667 |
| Secondary fumigator | 1.5 | 35 | 0.47 | 0.94 | 118 | 98 | 98 |
| Aerator 1 | 1.5 | 22 | 0.22 | 0.44 | 55 | 46 | 46 |
| Aerator 2 | 1.5 | 22 | 3.7 | 7.40 | 925 | 771 | 771 |
| | | | | Average | 490 | 408 | 408 |
| Forklift driver 1 | 1.5 | 460 | 0.33 | 0.66 | 69 | 55 | 55 |
| Forklift driver 2 | 1.5 | 399 | 0.15 | 0.30 | 31 | 25 | 25 |
| Forklift driver 3 | 1.5 | 452 | 0.23 | 0.46 | 48 | 38 | 38 |
| | | | | Average | 49 | 39 | 39 |
| | | | | STDEV | 19 | 15 | 15 |
| Catchall operator | 1.5 | 439 | 0.304 | 0.61 | 203 | 203 | 203 |
| Hopper operator 1 | 1.5 | 456 | 0.14 | 0.28 | 93 | 93 | 93 |
| Hopper operator 2 | 1.5 | 424 | 0.34 | 0.68 | 227 | 227 | 227 |
| | | | | Average | 160 | 160 | 160 |
| Capper dumper | 1.5 | 432 | 0.19 | 0.38 | 127 | 127 | 127 |
| Inspector | 1.5 | 471 | 0.023 | 0.05 | 15 | 15 | 15 |
| Moisture checker | 1.5 | 479 | 0.014 | 0.03 | 9 | 9 | 9 |
| Forklift to side hopper | 1.5 | 465 | 0.038 | 0.08 | 8 | 6 | 6 |
| Stem picker 1 | 1.5 | 498 | 0.042 | 0.08 | 28 | 28 | 28 |
| Stem picker 2 | 1.5 | 451 | 0.024 | 0.05 | 16 | 16 | 16 |
| Stem picker 3 | 1.5 | 365 | 0.031 | 0.06 | 21 | 21 | 21 |
| | | | | Average | 22 | 22 | 22 |
| | | | | STDEV | 6 | 6 | 6 |
| Packer 1 | 1.5 | 500 | 0.029 | 0.06 | 19 | 19 | 19 |

Table 29 (cont.1). Exposure of workers to MB during and after fumigation of dried fruit and tree nut products (4).

| Work task | Lbs MB/ 1,000 ft3 | Monit. time (min) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| **Area samples:** | | | | | | | |
| Shed-Green forklift | 1.5 | 31 | 0.56 | 1.12 | 117 | 93 | 93 |
| Shed-Blue tractor | 1.5 | 32 | 0.83 | 1.66 | 173 | 138 | 138 |
| Aeration-shed 604 | 1.5 | 33 | 2.8 | 5.60 | 700 | 583 | 583 |
| Aeration-shed 605 | 1.5 | 32 | 4 | 8.00 | 1,000 | 833 | 833 |
| Aeration-shed 606 | 1.5 | 32 | 8.7 | 17.40 | 2,175 | 1,813 | 1,813 |
| | | | | Average | 1,292 | 1,076 | 1,076 |
| | | | | STDEV | 780 | 650 | 650 |
| Capper area | 1.5 | 489 | 0.42 | 0.84 | 280 | 280 | 280 |
| Hopper area #2 | 1.5 | 444 | 0.091 | 0.18 | 61 | 61 | 61 |
| Catchoff area | 1.5 | 429 | 0.19 | 0.38 | 127 | 127 | 127 |
| Side hopper area | 1.5 | 478 | 0.034 | 0.07 | 23 | 23 | 23 |
| Stem picker area-A3 | 1.5 | 475 | 0.015 | 0.03 | 10 | 10 | 10 |
| Filler area, E-line | 1.5 | 476 | 0.029 | 0.06 | 19 | 19 | 19 |
| **d) Chamber (raisins):** | | | | | | | |
| Fumigator 1 | 1 | 41 | 0.57 | 1.71 | 107 | 107 | 71 |
| Fumigator 2 | 1 | 40 | 0.1 | 0.30 | 19 | 19 | 13 |
| | | | | Average | 63 | 63 | 42 |
| Aerator 1 | 1 | 3 | 0.34 | 1.02 | 64 | 64 | 43 |
| Aerator 2 | 1 | 3 | 0.16 | 0.48 | 30 | 30 | 20 |
| | | | | Average | 47 | 47 | 31 |
| Clear chamber 1 | 1 | 9 | 7.5 | 22.50 | 1,406 | 1,406 | 938 |
| Clear chamber 2 | 1 | 10 | 7.8 | 23.40 | 1,463 | 1,463 | 975 |
| | | | | Average | 1,434 | 1,434 | 956 |
| Stem picker 1 | 1 | 488 | 0.026 | 0.08 | 26 | 26 | 26 |
| Stem picker 2 | 1 | 486 | 0.03 | 0.09 | 30 | 30 | 30 |
| | | | | Average | 28 | 28 | 28 |
| Forklift driver | 1 | 536 | 0.02 | 0.06 | 3 | 3 | 1.0 |
| Hopper operator | 1 | 490 | 0.019 | 0.06 | 19 | 19 | 19 |
| Area sampling | | | | | | | |
| Fumigation chambers | 1 | 33 | 0.47 | 1.41 | 88 | 88 | 59 |
| Fumigation cage | 1 | 35 | 0.29 | 0.87 | 54 | 54 | 36 |
| Leak check-chamber 4 | 1 | 30 | 0.094 | 0.28 | 6 | n/a | n/a |
| Leak check-chamber 5 | 1 | 29 | 0.024 | 0.07 | 2 | n/a | n/a |
| | | | | Average | 4 | n/a | n/a |
| Aeration-chamber 4 | 1 | 8 | 0.99 | 2.97 | 186 | 186 | 124 |
| Aeration-chamber 5 | 1 | 9 | 0.25 | 0.75 | 47 | 47 | 31 |
| | | | | Average | 116 | 116 | 78 |
| Clearing-chamber 4 | 1 | 20 | 0.14 | 0.42 | 26 | 26 | 18 |
| Clearing-chamber 5 | 1 | 19 | 0.35 | 1.05 | 66 | 66 | 44 |
| | | | | Average | 46 | 46 | 31 |

Table 29 (cont.2). Exposure of workers to MB during and after fumigation of dried fruit and tree nut products (4).

| Work task | Lbs MB/ 1,000 ft3 | Monit. time (min) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| Hopper area | 1 | 498 | 0.002 | 0.01 | 2 | 2 | 2 |
| Hopper area, duplicate | 1 | 498 | 0.013 | 0.04 | 13 | 13 | 13 |
| | | | | Average | 8 | 8 | 8 |
| Stem picker | 1 | 479 | 0.029 | 0.09 | 29 | 29 | 29 |
| Stem picker, duplicate | 1 | 479 | 0.03 | 0.09 | 30 | 30 | 30 |
| Stem picker | 1 | 486 | 0.024 | 0.07 | 24 | 24 | 24 |
| Stem picker | 1 | 475 | 0.024 | 0.07 | 24 | 24 | 24 |
| | | | | Average | 27 | 27 | 27 |
| | | | | STDEV | 3 | 3 | 3 |
| **e) Fumigation of a vacuum and two non-certified chambers (walnut, shelled and in-shell):** | | | | | | | |
| Cracking-worker 1 | 3 | 606 | 1.2 | 2.80 | 933 | 933 | n/a |
| Cracking-worker 2 | 3 | 570 | 1.4 | 3.27 | 1,089 | 1,089 | n/a |
| Cracking-worker 3 | 3 | 607 | 1.3 | 3.03 | 1,011 | 1,011 | n/a |
| Cracking-worker 4 | 3 | 600 | 1.4 | 3.27 | 1,089 | 1,089 | n/a |
| Cracking-worker 5 | 3 | 598 | 1.2 | 2.80 | 933 | 933 | n/a |
| Cracking-worker 6 | 3 | 612 | 1.3 | 3.03 | 1,011 | 1,011 | n/a |
| Cracking-worker 7 | 3 | 261 | 2.3 | 5.37 | 1,789 | 1,789 | n/a |
| Cracking-worker 8 | 3 | 508 | 1.7 | 3.97 | 1,322 | 1,322 | n/a |
| Cracking-worker 9 | 3 | 608 | 1.4 | 3.27 | 1,089 | 1,089 | n/a |
| | | | | Average | 1,141 | 1,141 | n/a |
| | | | | STDEV | 269 | 269 | n/a |
| Sorting-worker 1 | 3 | 618 | 0.51 | 1.19 | 397 | 397 | n/a |
| Sorting-worker 2 | 3 | 613 | 0.67 | 1.56 | 521 | 521 | n/a |
| Sorting-worker 3 | 3 | 600 | 0.81 | 1.89 | 630 | 630 | n/a |
| Sorting-worker 4 | 3 | 616 | 0.99 | 2.31 | 770 | 770 | n/a |
| Sorting-worker 5 | 3 | 618 | 0.71 | 1.66 | 552 | 552 | n/a |
| Sorting-worker 6 | 3 | 489 | 0.77 | 1.80 | 599 | 599 | n/a |
| Sorting-worker 7 | 3 | 621 | 0.72 | 1.68 | 560 | 560 | n/a |
| Sorting-worker 8 | 3 | 620 | 0.92 | 2.15 | 716 | 716 | n/a |
| | | | | Average | 593 | 593 | n/a |
| | | | | STDEV | 116 | 116 | n/a |
| Fumigator 1 | 3 | 613 | 0.23 | 0.54 | 123 | 89 | 56 |
| Fumigator 2 | 3 | 614 | 0.55 | 1.28 | 294 | 214 | 134 |
| Fumigator 3-vac. chamber | 3 | 585 | 1.3 | 3.03 | 695 | 506 | 316 |
| Fumigator 4-vac. chamber | 3 | 524 | 2.1 | 4.90 | 1,123 | 817 | 510 |
| | | | | Average | 559 | 406 | 254 |
| | | | | STDEV | 446 | 324 | 203 |
| Cleaning-fumigator | 3 | 589 | 0.15 | 0.35 | 80 | 58 | 36 |
| Cleaning-sort 1 | 3 | 594 | 0.93 | 2.17 | 723 | 723 | n/a |
| Cleaning-sort 2 | 3 | 596 | 1.4 | 3.27 | 1,089 | 1,089 | n/a |
| Cleaning-sort 3 | 3 | 593 | 1.1 | 2.57 | 856 | 856 | n/a |
| | | | | Average | 889 | 889 | n/a |
| | | | | STDEV | 185 | 185 | n/a |

Table 29 (cont.3). Exposure of workers to MB during and after fumigation of dried fruit and tree nut products (4).

| Work task | Lbs MB/ 1,000 ft3 | Monit. time (min) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) Acute | Subchr.*** | Chr.*** |
|---|---|---|---|---|---|---|---|
| Bulk casing worker | 3 | 571 | 1.1 | 2.57 | 856 | 856 | n/a |
| In-shell-packer 1 | 3 | 462 | 1.2 | 2.80 | 933 | 933 | n/a |
| In-shell-packer 2 | 3 | 461 | 1.3 | 3.03 | 1,011 | 1,011 | n/a |
| | | | | Average | 972 | 972 | n/a |
| Hopper operator | 3 | 619 | 1 | 2.33 | 778 | 778 | n/a |
| Fumigator | 3 | 418 | 0.42 | 0.98 | 225 | 163 | 102 |
| **Area sampling:** | | | | | | | |
| Fumigatorium | 3 | 604 | 0.14 | 0.33 | 75 | 54 | 34 |
| Sorting area 1 | 3 | 645 | 0.68 | 1.59 | 529 | 529 | n/a |
| Sorting area 2 | 3 | 519 | 0.15 | 0.35 | 117 | 117 | n/a |
| | | | | Average | 323 | 323 | n/a |
| Cracking area | 3 | 582 | 1.4 | 3.27 | 1,089 | 1,089 | n/a |
| Vacuum chamber area | 3 | 596 | 2.3 | 5.37 | 1,789 | 1,789 | n/a |
| Cleaning Bldg-fum. | 3 | 600 | 1.5 | 3.50 | 802 | 583 | 365 |
| **f) Sea van aeration (dried unpackaged prunes):** | | | | | | | |
| Upwind of sea van | 3 | 119 | 0.18 | 0.42 | 9 | 9 | n/a |
| Downwind-center 1 | 3 | 15 | 0.66 | 1.54 | 32 | 32 | n/a |
| Downwind-center 2 | 3 | 45 | 0.3 | 0.70 | 15 | 15 | n/a |
| Downwind-center 3 | 3 | 61 | 0.16 | 0.37 | 8 | 8 | n/a |
| | | | | Average | 18 | 18 | n/a |
| | | | | STDEV | 13 | 13 | n/a |
| Downwind-left 1 | 3 | 15 | 0.3 | 0.70 | 15 | 15 | n/a |
| Downwind-left 2 | 3 | 45 | 0.22 | 0.51 | 11 | 11 | n/a |
| Downwind-left 3 | 3 | 60 | 0.14 | 0.33 | 7 | 7 | n/a |
| Downwind-right 1 | 3 | 16 | 0.84 | 1.96 | 41 | 41 | n/a |
| Downwind-right 2 | 3 | 45 | 0.31 | 0.72 | 15 | 15 | n/a |
| Downwind-right 3 | 3 | 62 | 0.25 | 0.58 | 12 | 12 | n/a |
| | | | | Average | 17 | 17 | n/a |
| | | | | STDEV | 12 | 12 | n/a |

*There was no indication in the report that air concentrations were adjusted for a recovery.

**adjusted by DPR based on rates shown in Appendix A and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of the MDL (10 ppb) was used for non-detects.

***subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

6. Worker exposure and on-site air monitoring studies at a walnut processing facility (Air Toxics LTD, 1995).

Report No. (status): Not assigned (Final)
Study Directors (company): Eric D. Winegar, David B. Curtis, Marie J. Yates (Air Toxics Limited).
Application information
Formulation: Not mentioned.
Application rate: Not mentioned.
Date of studies: 1993 (October 27 and 28; December 20 and 21), and 1994 (March 17 and 18; October 11 and 12).
Location: A walnut processing facility in Stockton.
Application method: The report indicated that methyl bromide was injected into Butler- or Polygon-type chambers. At the end of the fumigation period, chambers were aerated. The Butler chambers had a stack of sorts where the emission point was actually below the apex of the chamber. The Butler chambers were vented by a large fan system at the base of the chambers. The Polygon had no stack, only the openings at the top of the conical rooftop. These chambers were vented by a portable fan system that was inserted into an opening at the base of the chamber.

Air monitoring study
Work tasks/areas: (Monitoring times and replicates are shown in Table 31).
Exposure monitoring equipment: For worker exposure monitoring studies-Two or three tubes of petroleum charcoal sorbent tubes (2 of 200 mg, or 1 of 200 mg and 2 of 100 mg) and personal air sampling pumps. The flow rate was 30-40 mL/min. For area and on-site ambient air monitoring studies, identical sampling and analytical methods as that in the worker exposure monitoring studies were used. In addition, a few samples were collected into stainless steel canisters and analyzed by using the U.S. EPA Compendium method TO-14 (cryofocus GC/MS), which afforded a lower detection limits for those samples. The distance for area and on-site monitoring studies with respect to the source of MB could not be determined from the maps, which were included in the submitted report. The fumigation of walnuts during the peak of the season was continuous. The source of MB could be from the fumigation during the study or off-gassing from previously fumigated walnuts.

Air concentrations of MB from worker exposure and area monitoring studies were calculated and reported as the 24-hour TWA; monitoring times for replicates were not mentioned in the report. On-site ambient air concentrations of MB were reported as ppb; collection times for day- and night-monitoring periods were generally long (See Table 31).
Recovery: Recoveries ranged from 74 to 125%. However, the air concentrations were readjusted by DPR to reflect a recovery of 50% (Biermann and Barry, 1999; Helliker, 1999). The authors of this exposure assessment document did not make any correction to the reported values.

Exposure assessment

Air concentrations of MB are shown in three parts: a) worker exposures, b) area air monitoring data, c) on-site ambient air monitoring data. Off-site air monitoring data were not incorporated in this document.

Worker exposure monitoring were also conducted in 1992 (September 16 and 17). However, exposure data obtained from the 1992 studies were not used in this document because those studies were performed prior to modifications of the work practices and environment. The modifications after the 1992 studies included training of staff, increased air ventilation, and other changes in work practices such as the closer of the special cracking operation. The authors of this HS-report assume that these improved work practices and environment are in place at the present. Area sampling studies were conducted on the same dates as those for worker exposure studies in 1993 and 1994.

Air concentrations of MB as the 24-hour TWA for workers and area samples are shown in Table 31. Acute and non-acute exposure estimates are shown in Table 11.

Compliance monitoring study conducted by WH&S

On October 19, 1995, staff from the Worker Health and Safety Branch, DPR, conducted a full-shift monitoring study to determine the air concentration of MB at the four selected work stations at the Diamond Walnut facilities in Stockton (Gibbons, 1995). At each work station, three locations were chosen for the monitoring equipment. All samples were obtained as area samples and no personal samples were obtained. At all but one work station, the samplers were placed to sample air believed to be representative MB concentrations to which workers were being exposed. A representative of Air Toxics Limited also collected air samples from the same work stations. Results of this study were included in Table 31 for comparison with those obtained from a study previously performed by Air Toxics Limited.

Table 30. Exposure of workers to MB during and after fumigations of cherries for export in 1992 (5).

| Work task/site | Lbs MB/ 1,000 ft3 | Monitoring time (hrs) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.*** | Chronic*** |
| **Control room: start-up** | | | | | | | |
| Start-up at M&R | 3 | 2.4 | 2.69 | 6.19 | 258 | n/a | n/a |
| Start-up at M&R | 3 | 3.42 | 3.82 | 8.79 | 366 | n/a | n/a |
| Start-up at CCEA | 3 | 3 | 0.6 | 1.38 | 58 | n/a | n/a |
| Start-up at CCEA | 3 | 2 | 0.03 | 0.07 | 3 | n/a | n/a |
| | | | | Average | 171 | n/a | n/a |
| | | | | STDEV | 147 | n/a | n/a |
| **Control room: left overnight** | | | | | | | |
| Overnight at M&R | 3 | 8 | 0.27 | 0.62 | 26 | n/a | n/a |
| Overnight at M&R | 3 | 6.7 | 0.09 | 0.21 | 9 | n/a | n/a |
| Overnigh at CCEA | 3 | 8 | 0.02 | 0.05 | 2 | n/a | n/a |
| Overnigh at CCEA | 3 | 6.5 | 0.08 | 0.18 | 8 | n/a | n/a |
| | | | | Average | 11 | n/a | n/a |
| | | | | STDEV | 10 | n/a | n/a |
| **Fumigator** | | | | | | | |
| Start-up at M&R | 3 | 0.17 | 9.15 | 21.05 | 877 | n/a | n/a |
| Start-up at M&R | 3 | 0.17 | 2.44 | 5.61 | 234 | n/a | n/a |
| Start-up at CCEA | 3 | 0.17 | 0.84 | 1.93 | 81 | n/a | n/a |
| Start-up at CCEA | 3 | 0.5 | 1.21 | 2.78 | 116 | n/a | n/a |
| Start-up at CCEA | 3 | 0.17 | 0.82 | 1.89 | 79 | n/a | n/a |
| Start-up at CCEA | 3 | 0.17 | 2.28 | 5.24 | 219 | n/a | n/a |
| | | | | Average | 267 | n/a | n/a |
| | | | | STDEV | 306 | n/a | n/a |
| Closing-up at M&R | 3 | 0.17 | 2.28 | 5.24 | 219 | n/a | n/a |
| Closing-up at M&R | 3 | 0.17 | 4.54 | 10.44 | 435 | n/a | n/a |
| | | | | Average | 327 | n/a | n/a |
| Opening-up at M&R | 3 | 0.5 | 0.34 | 0.78 | 33 | n/a | n/a |
| Opening-up at M&R | 3 | 0.17 | 0.01 | 0.02 | 1 | n/a | n/a |
| Opening-up at M&R | 3 | 0.17 | 0.63 | 1.45 | 60 | n/a | n/a |
| Opening-up at M&R | 3 | 0.17 | 0.81 | 1.86 | 78 | n/a | n/a |
| Opening-up at CCEA | 3 | 0.5 | 0.62 | 1.43 | 59 | n/a | n/a |
| Opening-up at CCEA | 3 | 0.25 | 1.29 | 2.97 | 124 | n/a | n/a |
| Opening-up at CCEA | 3 | 0.25 | 1.17 | 2.69 | 112 | n/a | n/a |
| Opening-up at CCEA | 3 | 0.08 | 0.01 | 0.02 | 1 | n/a | n/a |
| | | | | Average | 58 | n/a | n/a |
| | | | | STDEV | 46 | n/a | n/a |
| **Forklift driver** | | | | | | | |
| at CCEA | 3 | 1.27 | 0.08 | 0.18 | 6 | n/a | n/a |
| at CCEA | 3 | 1.63 | 0.06 | 0.14 | 4 | n/a | n/a |
| at CCEA | 3 | 1.8 | 0.05 | 0.12 | 4 | n/a | n/a |
| at CCEA | 3 | 1 | 0.11 | 0.25 | 8 | n/a | n/a |
| at CCEA | 3 | 1.67 | 0.08 | 0.18 | 6 | n/a | n/a |
| at CCEA | 3 | 0.83 | 0.08 | 0.18 | 6 | n/a | n/a |
| at M&R | 3 | 1 | 0.65 | 1.50 | 47 | n/a | n/a |
| at M&R | 3 | 1 | 0.19 | 0.44 | 14 | n/a | n/a |
| at M&R | 3 | 1 | 0.08 | 0.18 | 6 | n/a | n/a |
| | | | | Average | 11 | n/a | n/a |
| | | | | STDEV | 14 | n/a | n/a |

Table 30 (cont.1). Exposure of workers to MB during and after fumigations of cherries for export in 1992 (5).

| Work task/site | Lbs MB/ 1,000 ft3 | Monitoring time (hrs) | MB conc.* ppm, v/v | MB conc.** ppm, v/v | 24-hr TWA (ppb) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.*** | Chronic*** |
| **Sorter (average)** | | | | | | | |
| M&R 1 | 3 | 5 | 0.11 | 0.25 | 84 | n/a | n/a |
| M&R 2 | 3 | 5 | 0.12 | 0.28 | 92 | n/a | n/a |
| M&R 3 | 3 | 5 | 0.1 | 0.23 | 77 | n/a | n/a |
| M&R 4 | 3 | 1 | 0.44 | 1.01 | 337 | n/a | n/a |
| M&R 5 | 3 | 1 | 0.16 | 0.37 | 123 | n/a | n/a |
| M&R 6 | 3 | 1.5 | 0.11 | 0.25 | 84 | n/a | n/a |
| M&R 7 | 3 | 1 | 0.14 | 0.32 | 107 | n/a | n/a |
| M&R 8 | 3 | 0.5 | 0.27 | 0.62 | 207 | n/a | n/a |
| M&R 9 | 3 | 1.25 | 0.34 | 0.78 | 261 | n/a | n/a |
| M&R 10 | 3 | 1 | 0.1 | 0.23 | 77 | n/a | n/a |
| M&R 11 | 3 | 1.23 | 0.12 | 0.28 | 92 | n/a | n/a |
| M&R 12 | 3 | 1 | 0.14 | 0.32 | 107 | n/a | n/a |
| CCEA 1 | 3 | 4.7 | 0.1 | 0.23 | 77 | n/a | n/a |
| CCEA 2 | 3 | 4.6 | 0.14 | 0.32 | 107 | n/a | n/a |
| CCEA 3 | 3 | 3.5 | 0.09 | 0.21 | 69 | n/a | n/a |
| CCEA 4 | 3 | 1 | 0.12 | 0.28 | 92 | n/a | n/a |
| CCEA 5 | 3 | 1 | 0.12 | 0.28 | 92 | n/a | n/a |
| CCEA 6 | 3 | 1 | 0.16 | 0.37 | 123 | n/a | n/a |
| | | | | Average | 123 | n/a | n/a |
| | | | | STDEV | 72 | n/a | n/a |

Compliance monitoring study (Gibbons, 1996)

| Work site | Lbs MB/ 1,000 ft3 | Monitoring time (hrs) | MB conc. (ppb) | MB conc.** (ppb) | 24-hr TWA (ppb) | | |
|---|---|---|---|---|---|---|---|
| | | | | | Acute | Subchr.*** | Chronic*** |
| Dump station | 3 | 6.2 | 31 | 71.30 | 24 | n/a | n/a |
| | 3 | 6.2 | 19 | 43.70 | 15 | n/a | n/a |
| | 3 | 6.2 | 12 | 27.60 | 9 | n/a | n/a |
| | 3 | 6.2 | 19 | 43.70 | 15 | n/a | n/a |
| | 3 | 6.2 | 35 | 80.50 | 27 | n/a | n/a |
| | | | | Average | 18 | n/a | n/a |
| | | | | STDEV | 7 | n/a | n/a |

M&R and CCEA represent sites of chambers.

*adjusted by the study director for a recovery, but the pecentage of recovery was not indicated in the report. It was assumed that 69% recovery was used.

**adjusted by DPR for an application rate of 5 lbs MB/1,000 ft3 and 50% recovery (Biermann and Barry, 1999; Helliker, 1999). One-half of MDL (10 ppb) was used for non-detects.

***subchr. (subchronic) and chr. (chronic) were used for the calculation of subchronic and chronic exposures shown in Table 11; hours/workday and workdays for subchronic and chronic exposures are shown in Appendix A.

Table 31. Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| | Work task | 24-hour TWA (ppb) | | | | |
|---|---|---|---|---|---|---|
| | | 10/1993* | 10/1994* | Acute | Subchr.** | Chr.** |
| **a) Worker exposure studies** | Bulk packaging | 26 | 22 | | | |
| | | 37 | 12 | | | |
| | | 0.5 | | | | |
| | | Average ('93-'94) | | 39 | 39 | n/a |
| | | STDEV ('93-'94) | | 28 | 28 | n/a |
| | Cleaning plant | 224 | 57 | | | |
| | | 34 | 175 | | | |
| | | 223 | 0.5 | | | |
| | | 145 | 167 | | | |
| | | 207 | 202 | | | |
| | | 18 | 17 | | | |
| | | | 158 | | | |
| | | | 85 | | | |
| | | | 31 | | | |
| | | | 174 | | | |
| | | | 10 | | | |
| | | | 170 | | | |
| | | Average ('93-'94) | | 233 | 233 | n/a |
| | | STDEV ('93-'94) | | 165 | 165 | n/a |
| | Dock 5 area | | 250 | 500 | 500 | n/a |
| | Fumigatorium | 1 | 53 | | | |
| | | 2 | 52 | | | |
| | | 0.5 | 25 | | | |
| | | Average ('93-'94) | | 45 | 32 | 20 |
| | | STDEV ('93-'94) | | 50 | 37 | 23 |
| | Packaging | 40 | 22 | | | |
| | | Average ('93-'94) | | 62 | 62 | n/a |
| | Vacuum chamber | 318 | 46 | | | |
| | | 88 | 233 | | | |
| | | 86 | 79 | | | |
| | | Average ('93-'94) | | 283 | 283 | n/a |
| | | STDEV ('93-'94) | | 216 | 216 | n/a |
| | Sorting | 21 | 10 | | | |
| | | 28 | 27 | | | |
| | | 35 | 23 | | | |
| | | 32 | 7 | | | |
| | | 17 | 12 | | | |
| | | 12 | 16 | | | |
| | | 11 | | | | |
| | | 20 | | | | |
| | | Average ('93-'94) | | 39 | 39 | n/a |
| | | STDEV ('93-'94) | | 17 | 17 | n/a |

Table 31 (cont. 1). Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| | Work task | 24-hour TWA (ppb) | | | | |
|---|---|---|---|---|---|---|
| | | 10/1993* | 10/1994* | Acute | Subchr.** | Chr.** |
| | Special cracking | 74 | 17 | | | |
| | | 75 | 16 | | | |
| | | 85 | 17 | | | |
| | | 54 | 8 | | | |
| | | 0.5 | | | | |
| | | 0.5 | | | | |
| | | 28 | | | | |
| | | 52 | | | | |
| | | 9 | | | | |
| | | 11 | | | | |
| | | 24 | | | | |
| | | 22 | | | | |
| | | Average ('93-'94) | | 62 | 62 | n/a |
| | | STDEV ('93-'94) | | 56 | 56 | n/a |

MDL was 0.1 ug/sample equivalent approx. to a single digit ppb detection limit. Since the lowest value of 1 ppb was reported, one-half of this value (0.5 ppb) was used whenever the MDL was shown in the submitted report.

| | Work | 24-hour TWA (ppb) | | | | |
|---|---|---|---|---|---|---|
| | | 1993* | 1994* | Acute | Subchr.** | Chr.** |
| **b) Area air monitoring studies** | Meats Pool | 63 | 51 | | | |
| (background samples) | | 6 | | | | |
| | | 21 | | | | |
| | | Average ('93-'94) | | 71 | n/a | n/a |
| | | STDEV ('93-'94) | | 53 | n/a | n/a |
| | Warehouse ('93) | 13 | | | | |
| | Warehouse isle ('94) | | 31 | | | |
| | | | 28 | | | |
| | | | 33 | | | |
| | | Average ('93-'94) | | 53 | n/a | n/a |
| | | STDEV ('93-'94) | | 18 | n/a | n/a |
| | Sorting line | 2 | 40 | | | |
| | | | 43 | | | |
| | | Average ('93-'94) | | 57 | n/a | n/a |
| | | STDEV ('93-'94) | | 46 | n/a | n/a |
| | West Alleyway | | 14 | 28 | n/a | n/a |
| | West Cage Door | | 10 | 20 | n/a | n/a |
| | East Alleyway | | 3 | 6 | n/a | n/a |
| | East Cage Door | | 3 | 6 | n/a | n/a |

Table 31 (cont. 2). Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| Sampling date | Chambers and the vicinity | Sampling time (hr) | Air conc. (ppb)* | 24-hour TWA (ppb) | | |
|---|---|---|---|---|---|---|
| | | | | Acute | Subchr.** | Chr.** |
| **c) On-site ambient air monitoring studies** | | | | | | |
| 10/28/93 | Butler 8/9 | 6.6 | 26 | 17 | n/a | n/a |
| | (the vicinity of fumigation chambers) | | | | n/a | |
| 10/28/93 | Polygon 19 | 6.6 | 16 | 11 | n/a | n/a |
| | (the vicinity of fumigation chambers) | | | | | |
| 11/19/93 | Polygon 20 | 2.07 | 653 | 435 | n/a | n/a |
| | (the vicinity of fumigation chambers) | | | | | |
| 11/19/93 | Polygon 20 | 2.1 | 310 | 207 | n/a | n/a |
| | (the vicinity of fumigation chambers) | | | | n/a | |
| 11/19/93 | Polygon 20 door (1,575 lbs. inj.) | 2.08 | 280 | 187 | n/a | n/a |
| | | | Average | 171 | n/a | n/a |
| | | | STDEV | 174 | n/a | n/a |
| | | | | | n/a | |
| 10/28/93 | Polygon 20 (within 20' of the injection) | 0.167 | 2100 | 1400 | n/a | n/a |
| 11/19/93 | Polygon 20 (within 20' of the injection) | 2.13 | 10200 | 6800 | n/a | n/a |
| | | | Average | 4100 | n/a | n/a |
| 12/16/93 | East fence | 3.68 | 1.9 | 1 | n/a | n/a |
| 12/16/93 | North gate | 3.65 | 7.0 | 5 | n/a | n/a |
| 12/16/93 | South center fence | 3.62 | 2.1 | 1 | n/a | n/a |
| 12/16/93 | West fenceline | 3.47 | 2.1 | 1 | n/a | n/a |
| 12/16/93 | Butler 3 vent area | 0.4 | 5.4 | 4 | n/a | n/a |
| | | | Average | 2 | n/a | n/a |
| | | | STDEV | 2 | n/a | n/a |
| 12/20/93 | Butler 11 | 2.95 | 243 | 162 | n/a | n/a |
| 12/20/93 | Butler 12 | 30.07 | 2900 | 1933 | n/a | n/a |
| 12/20/93 | Butler 13/14 | 3.3 | 264 | 176 | n/a | n/a |
| 12/20/93 | Butler 13/15 | 3.08 | 48 | 32 | n/a | n/a |
| | | | Average | 576 | n/a | n/a |
| | | | STDEV | 907 | n/a | n/a |
| 12/20/93 | East fenceline | 3.88 | 2.9 | 2 | n/a | n/a |
| 12/20/93 | East fenceline | 3.07 | 6.9 | 5 | n/a | n/a |
| 12/20/93 | North fenceline | 3.6 | 2.7 | 2 | n/a | n/a |
| 12/20/93 | North fenceline | 3.08 | 4 | 3 | n/a | n/a |
| 12/20/93 | North gate | 3.78 | 2.2 | 1 | n/a | n/a |
| 12/20/93 | North gate | 3.05 | 2.9 | 2 | n/a | n/a |
| | | | Average | 2 | n/a | n/a |
| | | | STDEV | 1 | n/a | n/a |

Notes: Fumigation chamber types.
a) Polygon: vol. 671,000&959,000 ft3, stack height 80 ft (openings are at the top of the conical rooftop), fan flow rate 14,400 CFM (sum of two ports). b) Butler: vol. 151,000 ft3, stack height 65 ft, fan flow rate 1,750 CFM. Both chamber types do not have the standard stack height, which is 10' above the highest point of the chamber. Before the study was conducted, those chambers have not been USDA pressure tested.

Table 31 (cont. 3). Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| Sampling date | Chambers and the vicinity | Sampling time (hr) | Air conc. (ppb)* | 24-hour TWA (ppb) | | |
|---|---|---|---|---|---|---|
| | | | | Acute | Subchr.** | Chr.** |
| 12/20/93 | Polygon 20, on door | 0.33 | 6.5 | 4 | n/a | n/a |
| 12/20/93 | Polygon 20 area | 3.8 | 2.8 | 2 | n/a | n/a |
| 12/20/93 | Polygon 20 area | 3.02 | 4.5 | 3 | n/a | n/a |
| 12/20/93 | Polygon 20 area | 3.03 | 5.4 | 4 | n/a | n/a |
| 12/20/93 | Polygon 20 area | 1.32 | 7.9 | 5 | n/a | n/a |
| 12/20/93 | Butler 12 | 2.57 | 4.3 | 3 | n/a | n/a |
| 12/20/93 | Butler 13/14 | 2.6 | 19 | 13 | n/a | n/a |
| | | | Average | 5 | n/a | n/a |
| | | | STDEV | 4 | n/a | n/a |
| 12/20/93 | South center fence | 3.2 | 4.4 | 3 | n/a | n/a |
| 12/20/93 | South center fence | 3.08 | 3.5 | 2 | n/a | n/a |
| 12/20/93 | West fenceline | 3.8 | 3.3 | 2 | n/a | n/a |
| 12/20/93 | West fenceline | 3.03 | 5.7 | 4 | n/a | n/a |
| 12/20/93 | South center fence | 3.08 | 3.5 | 2 | n/a | n/a |
| | | | Average | 3 | n/a | n/a |
| | | | STDEV | 0.7 | n/a | n/a |
| (Notes: wind speed on 12/20/93 ranged from 2.2-10.8 mph; temp (oC) ranged from 2.2-4.4; "xx" ppb was used when it was reported as "< xx" ppb) | | | | | | |
| 3/11/94 | Butler 11 | 5.02 | 121 | 81 | n/a | n/a |
| 3/11/94 | Butler 4 | 4.05 | 2200 | 1467 | n/a | n/a |
| 3/11/94 | Butler 16/17 | 4.02 | 143 | 95 | n/a | n/a |
| | | | Average | 548 | n/a | n/a |
| | | | STDEV | 796 | n/a | n/a |
| 3/17/94 | Butler 1 | 5.23 | 7.1 | 5 | n/a | n/a |
| 3/17/94 | Butler 15/16 | 5.25 | 36 | 24 | n/a | n/a |
| 3/17/94 | Butler 17/18 | 5.27 | 70 | 47 | n/a | n/a |
| 3/17/94 | Butler 2 | 3.92 | 15 | 10 | n/a | n/a |
| 3/17/94 | Butler 11/12 | 3.92 | 2.3 | 2 | n/a | n/a |
| | | | Average | 17 | n/a | n/a |
| | | | STDEV | 18.5 | n/a | n/a |
| 3/17/94 | North fenceline | 5.5 | 2.1 | 1 | n/a | n/a |
| 3/17/94 | South center fenceline | 5.25 | 53 | 35 | n/a | n/a |
| 3/17/94 | South center fenceline | 3.95 | 7.9 | 5 | n/a | n/a |
| | | | Average | 14 | n/a | n/a |
| | | | STDEV | 18.6 | n/a | n/a |

(Notes: wind speed on 3/17/94 ranged from 4.8-9.5 mph; temp (oC) ranged from 9.4-19.8)

Table 31 (cont. 4). Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| Sampling date | Chambers and the vicinity | Sampling time (hr) | Air conc. (ppb)* | 24-hour TWA (ppb) | | |
|---|---|---|---|---|---|---|
| | | | | Acute | Subchr.** | Chr.** |
| 10/25/94-Day | Lamp post | 13.15 | 3.8 | 6.3 | | |
| 10/25/94-Night | Lamp post | 10.76 | 2.5 | | | |
| 10/26/94-Day | Lamp post | 12.32 | 1.6 | 3.8 | | |
| 10/26/94-Night | Lamp post | 11.48 | 2.2 | | | |
| | | | Average | 5 | n/a | n/a |
| 10/25/94-Day | North fence | 12.7 | 1.9 | 5.8 | | |
| 10/25/94-Night | North fence | 12.03 | 3.9 | | | |
| 10/26/94-Day | North fence | 11.25 | 20 | 21.9 | | |
| 10/26/94-Night | North fence | 12.1 | 1.9 | | | |
| | | | Average | 14 | n/a | n/a |
| 10/25/94-Night | North gate | 11.85 | 1.8 | 3.6 | | |
| 10/26/94-Day | North gate | 3.28 | 6 | 7.9 | | |
| 10/26/94-Night | North gate | 11.33 | 1.9 | | | |
| | | | Average | 6 | n/a | n/a |
| 10/25/94-Day | Pallets | 12.88 | 1.8 | 8.9 | | |
| 10/25/94-Night | Pallets | 11.33 | 7.1 | | | |
| 10/26/94-Day | Pallets | 11.85 | 26 | 64 | | |
| 10/26/94-Night | Pallets | 11.33 | 38 | | | |
| | | | Average | 36 | n/a | n/a |
| 10/25/94-Day | Polygon fence | 10.17 | 8.6 | 21.6 | | |
| 10/25/94-Night | Polygon fence | 12.65 | 13 | | | |
| 10/26/94-Day | Polygon fence | 12.38 | 1.6 | 3.7 | | |
| 10/26/94-Night | Polygon fence | 11.43 | 2.1 | | | |
| | | | Average | 13 | n/a | n/a |
| 10/25/94-Day | Polygon ramp | 11.08 | 45 | 47.2 | | |
| 10/25/94-Night | Polygon ramp | 10.95 | 2.2 | | | |
| 10/26/94-Day | Polygon ramp | 12.13 | 55 | 72 | | |
| 10/26/94-Night | Polygon ramp | 11.43 | 17 | | | |
| | | | Average | 60 | n/a | n/a |
| 10/25/94-Night | Rooftop | 12.27 | 6.6 | 13.2 | | |
| 10/26/94-Night | Rooftop | 11.35 | 8.1 | 1 | | |
| | | | Average | 7 | n/a | n/a |
| 10/25/94-Day | Scale house | 12.6 | 18 | 24.9 | | |
| 10/25/94-Night | Scale house | 11.67 | 6.9 | | | |
| 10/26/94-Day | Scale house | 11.548 | 7.9 | 12.3 | | |
| 10/26/94-Night | Scale house | 11.32 | 4.4 | | | |
| | | | Average | 19 | n/a | n/a |

Table 31 (cont. 5). Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| Sampling date | Chambers and the vicinity | Sampling time (hr) | Air conc. (ppb)* | 24-hour TWA (ppb) | | |
|---|---|---|---|---|---|---|
| | | | | Acute | Subchr.** | Chr.** |
| 10/25/94-Day | South center fence | 13 | 7.4 | 11.2 | | |
| 10/25/94-Night | South center fence | 11.1 | 3.8 | | | |
| 10/26/94-Day | South center fence | 12 | 37 | 45.7 | | |
| 10/26/94-Night | South center fence | 11.45 | 8.7 | | | |
| 10/25/94-Day | South west fence | 12.93 | 1.5 | 3.3 | | |
| 10/25/94-Night | South west fence | 11.33 | 1.8 | | | |
| 10/26/94-Day | South west fence | 11.83 | 15 | 20 | | |
| 10/26/94-Night | South west fence | 11.33 | 5 | | | |
| | | | Average | 20 | n/a | n/a |
| | | | STDEV | 18 | n/a | n/a |
| 10/25/94-Day | Storage area | 6.73 | 2.3 | 4.3 | | |
| 10/25/94-Night | Storage area | 11.12 | 2 | | | |
| 10/26/94-Day | Storage area | 11.9 | 1.1 | 3.3 | | |
| 10/26/94-Night | Storage area | 9.17 | 2.2 | | | |
| | | | Average | 4 | n/a | 4 |
| 10/25/94-Day | Warehouse dock | 12.85 | 9.8 | 24.8 | | |
| 10/25/94-Night | Warehouse dock | 11.52 | 15 | | | |
| 10/26/94-Day | Warehouse dock | 11.7 | 165 | 198 | | |
| 10/26/94-Night | Warehouse dock | 11.33 | 33 | | | |
| | | | Average | 111 | n/a | 111 |
| 10/25/94-Night | West fence | 12.32 | 4.3 | 8.6 | | |
| 10/26/94-Day | West fence | 3.37 | 6.9 | 12.2 | | |
| 10/26/94-Night | West fence | 11.5 | 5.3 | | | |
| | | | Average | 10 | n/a | n/a |
| **d) Compliance monitoring (Gibbons, 1995) (10/19/95)** | | | | | | |
| Sorting line in cleaning plant (12-hr shift) | | | | | | |
| | Nut exit - sorting line #1 | 12 | 287 | 287 | | |
| | Nut exit - sorting line #2 | 12 | 324 | 324 | | |
| | Nut entrance manifold, line #2 | 12 | 343 | 343 | | |
| | | | Average | 318 | 318 | n/a |
| | | | STDEV | 28 | 28 | n/a |
| Cello packaging of in-shell walnuts in main building (9-hr shift) | | | | | | |
| | Packing machine #11 - power box | 2.9 | 485 | 364 | | |
| | Packing machine #9 - power box | 8.5 | 435 | 326 | | |
| | Column by boxing person near #9 | 8.5 | 500 | 375 | | |
| | | | Average | 355 | 355 | n/a |
| | | | STDEV | 26 | 26 | n/a |

Table 31 (cont. 6). Methyl bromide air concentrations obtained from worker exposure studies, and area and on-site air monitoring studies at a walnut processing plant in Stockton (6).

| Sampling date | Chambers and the vicinity | Sampling time (hr) | Air conc. (ppb)* | 24-hour TWA (ppb) | | |
|---|---|---|---|---|---|---|
| | | | | Acute | Subchr.** | Chr.** |
| Bulk packaging of in-shell walnuts in main building (11-hr shift) | | | | | | |
| | Column by stitching station | 10.7 | 264 | 242 | | |
| | Control panel - bag filling | 9.6 | 267 | 245 | | |
| | On stitching machine | 10.7 | void | - | | |
| | | | Average | 243 | 243 | n/a |
| Truck dumping work station near dock 5 area | | | | | | |
| | Foreman's desk top | 10.7 | 402 | 369 | 369 | 369 |
| | Foreman's desk, phone box shelf | 10.8 | 31 | 28 | 28 | 28 |
| | Fence between chamber 2 and 3 | 10.7 | 523 | 479 | n/a | n/a |

* as shown in the submitted report. It was assumed that air concentrations were adjusted using the mid-point recovery (99.5%) of a recovery range of 74-125%.

** The calculation procedure for daily non-acute exposures are as follows:
Daily subchronic MB conc. = (Daily acute MB conc. x daily subchronic exposure time (hrs))/daily acute exposure time (hours). The same method was used for the calculation of daily chronic exposures.
Acute, subchronic and chronic exposures were adjusted for 50% recovery.

7. Space-type fumigation: Potential worker exposure to MB at a brewery facility (Gibbons, 1994).

Application information
Formulation: Not mentioned
Application rate: Not mentioned
Date of application: November 26, 1992
Location (area treated): Fairfield (area was not known)
Use of tarpaulin: No
Application method: During the application of fumigation, two applicators wearing Self-Contained Breathing Apparatus (SCBA) made repeated entry into the grain storage and processing areas to open pre-placed small MB canisters and large cylinders. The canisters were used to treated the inside of numerous enclosed pipes and other equipment which were used for transferring the grain. The large cylinders were used to treat the enclosed air spaces surrounding the equipment. After the fumigation was done, the fumigated area was left undisturbed for 24 hours. During the aeration phase, two workers wearing SCBA made two entries into the space to initiate the aeration. Work tasks during application and aeration are listed in Table 32.

Air monitoring study
Work tasks (monitoring time, replicates): Applicators (5-36 min, n=4), aerators (6-24 min, n=4).
Exposure monitoring equipment: Not reported
Recovery: Not reported

Exposure assessment
DPR conducted the monitoring study designed to gather data on potential worker exposure associated with the space-type fumigation at a brewery facility and during the aeration on the

following day. Results are shown in Table 32. The air concentrations as shown are potential exposure and not actual exposure. Acute and non-acute exposure estimates are shown in Table 11.

Table 32. Monitoring of methyl bromide during space fumigation and aeration at a brewery facility (7).*

| Activity | Monit. time (minutes) | MB conc. (ppm) | Protection factor-PF** | Estimated exposure (ppb) | Estimated exposure, ppb*** (24-hr TWA) |
|---|---|---|---|---|---|
| a) Applicator (one applicator, 4 samples (s)) | | | | | |
| Appl. 1, s 1- entry to open canisters | 14 | 298 | 10,000 | 29.8 | |
| Appl. 1, s 2 - reentry to open canisters | 36 | 3624 | 10,000 | 362.4 | 28.9 |
| Appl. 1, s 3 - reentry to open canisters | 11 | 3871 | 10,000 | 387.1 | |
| Appl. 1, s 4 - reentry to open large cylinders | 5 | 6117 | 10,000 | 611.7 | |
| Area sample (door to buffer zone) | 1530 | 635 | 10,000 | 63.5 | 42 |
| b) Aerator (two aerators, 4 samples) | | | | | |
| Aerator 1, s 1 | 24 | 7016 | 10,000 | 701.6 | |
| Aerator 1, s 2 | 20 | 169 | 10,000 | 16.9 | 24 |
| Aerator 2, s 1 | 19 | 9546 | 10,000 | 954.6 | |
| Aerator 2, s 2 | 6 | 11.4 | 10,000 | 1.14 | 25 |
| | | | | Average | 25 |
| Area sample (left of entrance door)(*) | 70 | 0.26 | n/a | 260 | 173 |
| Area sample (on applicator's truck)(*) | 55 | 0.15 | n/a | 150 | 100 |

* workers wore SCBA during the application and aeration processes. Detected MB concentrations represent potential exposures.

** a protection factor (PF) (NIOSH, 1987) was used to derive estimated exposure.

*** calculated based on serial sampling for an applicator and two aerators. It was assumed that the indicated monitoring times were similar to actual exposure times. Exposures were adjusted by DPR for 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

(*) It was assumed that workers may work in areas where samples were collected under area samples during aeration; SCBA are not typically used by these workers.

## Appendix C
## Residential Exposure Studies

DowElanco submitted a study conducted by the University of Florida in support of sulfuryl fluoride registration (Bloomcamp *et al*., 1991). The same report also contained data on MB indoor air concentrations after subsequent aeration of 10 fumigated homes. These homes were fumigated with MB at a rate of 16 g/$m^3$ and thereafter aerated to 5 ppm according to U. S. EPA-approved procedures. However, the air concentration substantially increased (19.2 ± 10.9 ppm) after the doors and windows were closed for two hours. Homes were aerated and closed again. During the second 2-hour closure, MB concentration increased above 5 ppm in four homes (18.6 ± 5.4 ppm). This study was conducted to better characterize the fate of indoor air concentrations of the fumigant following aeration.

A second submitted report related to indoor fumigation was conducted because of a request to modify a method to release MB into the fumigated structure (Soil Chemicals Corp., 1980). Results from three tests indicated that equilibrium of the fumigant can be best achieved by shooting gas into the attic. Data indicated that the gas initially tends to move in a downward direction. When the gas was shot into the living space, the attic was the last area to reach equilibrium. This report did not provide appropriate indoor air concentration to estimate exposure of residents.

8.a. Residents/bystanders (outdoor and indoor air concentrations of MB near fumigated single-family houses (Gibbons *et al*., 1996a).

Report No. (status): HS-1717 (final)
Study Director (Affiliation): Dennis Gibbons (WH&S, DPR)

Application information
Formulation: 99.5% MB, 0.5% chloropicrin (Meth-O-Gas)
Application rate: 3 Lbs formulated product/1,000 $ft^3$
Date of application: Winter and Spring of 1993, 1994
Location (area treated): A house in the former Mather Air Force Base, Sacramento, CA.
Use of tarpaulin: Yes
Application method:

Prior to each fumigation, a two- or three-man crew used industry-standard tarpaulins to fully cover a single-family house. Sand-filled canvas tubes (sand snakes) were used to seal the edges of the tarpaulins near the soil. The crew then set up the injection system, consisting of a 150-pound MB tank, a high-pressure hose connected to a propane-powered water heater to warm the gas, and an injector hose which was extended into the house. It took about 25 minutes to inject 62 Lbs of MB into the house which had a volume of about 20,700 $ft^3$. The fumigation was conducted in the morning and lasted about 22-24 hours. The same house was fumigated seven different times (replicates).

Air monitoring study

Indoor monitoring (time (hours), replicates): 24, n=27 (excluded a house with faulty sewer connection). Samples of air were collected from five neighboring houses. The sampling stations were set in rooms closest to the fumigated house. Three houses were within about 50 feet of the fumigated house. Two other houses were within about 100 feet of the fumigated houses. All door and windows were kept closed during sample collection, with only intermittent front door opening to replace sampling media. Air samples were collected using petroleum-based charcoal tubes (400/200 mg charcoal) connected to air sampling pumps. These tubes were elevated 4-5 feet above the floor. All samplers were calibrated to draw no more than 10 to 11 liters of air through each set of sampling tubes in a sampling period. Just before each study, background air samples were also collected in each house, including the fumigated structure.

Exterior monitoring time (hours, replicates): 24, n = 44. The exterior monitoring study used the same air pump and sampling media set-up for indoor air monitoring. Air samples were collected 10 feet from the outer surface of the tarpaulin. Air samples collected at 50 feet (n = 3) from the outer surface of the tarpaulin yielded no detectable MB. Air sampling media were elevated 4-5 feet above the ground. For the 24-hour sample collection, charcoal tubes were replaced with new ones after about 12 hours of collection. Air sampling was initiated a few minutes after the fumigation crew began the injection of the gas.

Exposure monitoring equipment: Petroleum-based charcoal tubes (primary-400 mg of charcoal and secondary (backup)-200 mg charcoal), air sampling pumps, metal stake used to hold sampling tube 4-5 feet above the ground, charger unit for long-term powering of the pump. All samplers were calibrated to draw no more than a total of 10 to 12 liters of air through the sampling tubes in a sampling period.

Analysis (recovery): MB in sampling tubes was extracted with ethyl acetate. The extract was analyzed by gas-liquid chromatography equipped with electron-capture detector. Lab spiked recovery studies were conducted using three levels of MB (μg): High (8.52), medium (4.26 and 2.26), and low (0.85 and 1.13). The average analytical recovery was 71.4% (49-102%). Average recovery was used to adjust MB air concentration data. This study was not conducted in compliance with GLP (40 CFR 160) of the U.S. Environmental Protection Agency.

Exposure/data assessment

Results are shown in Table 33. The authors have determined that residents who live in or nearby fumigated homes will not have subchronic or chronic exposure to MB because continuous fumigation of neighboring homes does not occur.

Table 33. Outdoor and indoor air concentrations of MB near fumigated single-family houses (8.a)

**Before correction for 50% recovery.**

| | | | Range (ppm) | | | |
|---|---|---|---|---|---|---|
| | Distance (ft) | Replicate | Mean | Minimum*** | Maximum | 95th percentile |
| **Outdoor air*** | 10 | 44 | 0.261 | 0.019 | 1.495 | 0.665 |
| **Indoor air**** | Neighboring house | 27 | 0.012 | 0.012 | 0.203 | 0.081 |

**After correction for 50% recovery.**

| | | | Range (ppm) | | | |
|---|---|---|---|---|---|---|
| | Distance (ft) | Replicate | Mean | Minimum*** | Maximum | 95th percentile |
| **Outdoor air*** | 10 | 44 | 0.522 | 0.038 | 2.990 | 1.330 |
| **Indoor air**** | Neighboring house | 27 | 0.024 | 0.024 | 0.406 | 0.162 |

* at 10 feet outside the tarpaulin that enclosed the fumigated house. MB air concentrations were adjusted by DPR for 50% recovery (Biermann and Barry, 1999; Helliker, 1999).

** rooms closest to the fumigated house at the distance of about 50-100 feet. Results excluded data from a house with faulty sewer connection.

*** the non-detectable level was less than 0.012 ppm.

8.b. Residents/bystanders (downwind outdoor and indoor air concentrations of MB during aeration of fumigated single-family houses (Gibbons *et al*., 1996b).

Report No. (status): HS-1713 (final)
Study Director (Affiliation): Dennis Gibbons (WH&S, DPR)

Application information
Formulation: 99.5% MB, 0.5% chloropicrin
Application rate: 3 Lbs formulated product/1,000 $ft^3$
Date of application: Winter and Spring of 1993, 1994
Location (area treated): A house in the Former Mather Air Force Base, Sacramento, CA.
Use of tarpaulin: Yes
Application method:

Prior to each fumigation, a two- or three-man crew used industry-standard tarpaulins to fully cover a single-family house. Sand-filled canvas tubes (sand snakes) were used to seal the edges of the tarpaulins near the soil. The crew then set up the injection system, consisting of a 150-pound MB tank, a high-pressure hose connected to a propane-powered water heater to warm the gas, and an injector hose which was extended into the house. It took about 25 minutes to inject 62 Lbs of MB into the house which has a volume of about 20,700 $ft^3$. The fumigation was conducted in the morning and lasted about 22-24 hours. The same house was fumigated seven different times (replicates).

The crew aerated the house 22 to 24 hours after application of MB. The two aeration methods used were the standard method and the method used by the Pest Control Operators of California (PCOC, 1994). In addition to procedures used in the first method, the PCOC

method requires that before the tarpaulins are removed, a fan be used to exhaust the fumigant-containing air upward from the space between the tarpaulin and the house (innerspace). This procedure lasts 15 minutes. The PCOC method is required by present permit conditions and it is the industry standard aeration method. Hence, air concentrations of MB used in this document are those based on the PCOC aeration method.

Air monitoring study

Exterior monitoring (time, replicates):

Collection of air samples downwind from the fumigated house: 10 feet (1 hr, 24 hrs; n=36), 50 feet (1 hr, 24 hrs; n=19), 100 feet (1 hr, 24 hrs; n=18). For the 24-hour sample collection, charcoal tubes were replaced with new ones after 10-12 hours of collection. Air sampling was initiated just prior to the crew removing the first clip or sandsnake.

Indoor monitoring (time (hours), replicates):

Samples of air were collected from five neighboring houses. The sampling stations were set in rooms closest to the fumigated house. Three houses were within about 50 feet of the fumigated house. Two other houses were within about 100 feet of the fumigated houses. All door and windows were kept closed during sample collection, with only intermittent front door opening to replace sampling media. Air sampling tubes were elevated 4-5 feet above the floor. Just before each study, background air samples were also collected in each house, including the fumigated structure.

Exposure monitoring equipment: Petroleum-based charcoal tubes (primary-400 mg of charcoal and secondary (backup)-200 mg charcoal), air sampling pumps, metal stake used to hold sampling tube 4-5 feet above the ground, charger unit for long-term powering of the pump. All samplers were calibrated to draw no more than a total of 10 to 12 liters of air through the sampling tubes in a sampling period.

Analysis (recovery): MB in sampling tubes was extracted with ethyl acetate. The extract was analyzed by gas-liquid chromatography equipped with electron capture detector. Lab spiked recovery studies were conducted using three levels of MB (μg)-high (8.52), medium (4.26 and 2.26), and low (0.85 and 1.13). The average analytical recovery was 71.4% (49-102%). Average recovery was used to adjust MB air concentration data. This study was not conducted in compliance with GLP (40 CFR 160) of the U.S. Environmental Protection Agency.

Exposure/data assessment

Results are shown in Table 34. The authors have determined that residents who live in or nearby fumigated homes will not have subchronic or chronic exposure to MB because continuous fumigation of neighboring homes does not occur.

Table 34. Downwind outdoor and indoor air concentrations of MB during aeration of fumigated single-family houses (8.b).

**Before adjustment for 50% recovery.**

| | | | Range (ppm) | | |
|---|---|---|---|---|---|
| | Distance (ft) | Replicate | Mean | Minimum** | Maximum |
| **Outdoor air** | 10 | 19 | 0.148 | 0.012 | 0.532 |
| | 50 | 10 | 0.04 | 0.012 | 0.104 |
| | 100 | 9 | 0.02 | 0.012 | 0.037 |
| **Indoor air** | Neighboring house | 12 | 0.03 | 0.012 | 0.084 |

**After adjustment for 50% recovery.**

| | | | Range (ppm) | | |
|---|---|---|---|---|---|
| | Distance (ft) | Replicate | Mean | Minimum** | Maximum |
| **Outdoor air** | 10 | 19 | 0.296 | 0.024 | 1.064 |
| | 50 | 10 | 0.080 | 0.024 | 0.208 |
| | 100 | 9 | 0.040 | 0.024 | 0.074 |
| **Indoor air** | Neighboring house | 12 | 0.060 | 0.024 | 0.168 |

* adjusted by DPR for 50% recovery (Biermann and Barry, 1999; Helliker, 1999).
** the non-detectable level was less than 0.012 ppm.

9. Exposure of residents to methyl bromide during reentry into fumigated houses.

Residents can be exposed to airborne MB after reentry into their fumigated houses following aeration. MB product labels require a minimum active aeration period (e.g., using fans) of 72 hours and the level of MB must be less than 3 ppm measured in the ground receptacle of an interior electrical outlet or other enclosed space within the wall or an interior and a perimeter wall. The aeration period must last for a minimum of 7 days if non-mechanical or natural ventilation is used.

According to the current MB product labels, general fumigation rates range from 1 to 3 Lbs MB 99.5% per 1,000 $ft^3$. Under adverse conditions, the fumigation rate may be increased from 3 ½ to 3 ¾ Lbs per 1,000 $ft^3$. In 1995, Southern California counties used 529,390 Lbs MB or 88% of total MB used for structural fumigation (Table 35) (EM&PM, 1998). A typical structural fumigation rate used in these counties was 1.5 Lbs MB/1,000 $ft^3$ (Sansone, 1998). A fumigation rate of 1.25 Lbs MB/1,000 $ft^3$ has also been used for some bigger projects. For structural fumigation in Northern California, typical structural fumigation rates for the control of dry wood termites ranged from 2 to 2.5 Lbs MB/1,000 $ft^3$ and that for powder post beetles ranged from 2.5 to 3.0 Lbs MB/1,000 $ft^3$ (Sansone, 1998). For residential exposure estimation, a fumigation rate of 1.5 Lbs MB/1,000 $ft^3$ was used for structural fumigation in Southern California and a fumigation rate of 3.0 Lbs MB/1,000 $ft^3$ was used for structural fumigation in Northern California.

Scheffrahn *et al.* (1992) conducted a study in 1990 that demonstrated MB levels were greater than 5 ppm in fumigated houses after aerated to less than 5 ppm and subsequently closed. Consequently, the Worker Health and Safety Branch conducted studies in 1992 to determine MB concentrations in fumigated houses after active aeration (Gibbons, 1992). These houses were fumigated with MB at a rate of 1.5 Lbs/1,000 $ft^3$.

Consolidated air concentrations of MB measured in five houses after a 24-hour active aeration period are shown in Table 36 under measured MB concentrations. Air concentrations measured in a house identified as "Site Six" (Gibbons, 1992) was not included because of a short sampling period. The MB concentrations from five houses ranged from 0.070 ppm to 1.740 ppm depending on the sampling time. A regression line for MB concentrations was generated by using a scientific software SigmaPlot™ (Jandel Scientific, 1994) and is shown in Figure 1.

There were no measurements for MB concentrations after 92 hours as shown in Table 36. A regression analysis was performed to extrapolate air concentrations (for a fumigation rate of 1.5 Lbs MB/1,000 $ft^3$) beyond 24-hour aeration generated by using a scientific software SigmaPlot™ (Jandel Scientific, 1994). This extrapolation was done in order to estimate MB concentrations after 72 hours of active aeration. The exposure of residents was assumed to occur during a 7-day period following 72-hour aeration. Thereafter, MB in the fumigated houses would be dissipated and residents would not be subjected to subchronic exposure as defined by Sanders (1998) (e.g., more than 30-day exposure in a 90-day period). The MB data were extrapolated after 48 hours to 216 hours (216 - 48 = 168 hours or 7 days) after 72 hour aeration (24 + 48 hrs). The MB air concentrations of 86 ±73 ppb (range 15 - 229 ppb) for subacute exposure during the 7-day period following 72-hour aeration are shown in Table 37. The regression line is shown in Figure 2.

A similar extrapolation was performed for the MB data based upon a fumigation rate of 3 Lbs MB/1,000 $ft^3$, which is a typical rate used in Northern California counties (Sansone, 1998). The mean MB concentration for subacute exposure is 172 ± 147 ppb (range 30 - 458 ppb).

A regulatory limit of 210 ppb is used for acute exposure of residents during reentry into fumigated houses because there was no actual MB measurement. Without actual exposure data, the use of this regulartory limit should be more reliable than using an estimated exposure. The following calculations demonstrate that the use of 210 ppb for acute exposure of residents, who live in fumigated houses or houses located near fumigated fields or commodity fumigation facilities, is appropriate.

Ideal gas law $C_1V_1 = C_2V_2$

Or $C_2 = (V_1/V_2)\, C_1$

Active ventilation (e.g., 3,000 $ft^3$/min) period 3 days

MB levels in wall voids ($V_1$) (measured in electrical sockets) 3 ppm ($C_1$)

Exposure potential to reoccupants ($C_2$) in fumigated houses ($V_2$):

WV/DV(or $V_1/V_2$) = 0.056 ± 0.004 (Johnson, 1992)

$C_2$ = 0.056 x 3,000 ppb

= <u>168 ppb</u>

(WV, wall volume; DV, dwelling volume)

Table 35. Use of methyl bromide in structural fumigations in California in 1995

| | Lbs MB | |
|---|---|---|
| County | California | So. CA county |
| Alameda | 4,610 | |
| Amador | 447 | |
| Butte | 146 | |
| Calaveras | 356 | |
| Colusa | 111 | |
| Contra Costa | 2,074 | |
| El Dorado | 433 | |
| Fresno | 1,210 | |
| Humbolt | 80 | |
| Kern | 488 | |
| Kings | 199 | |
| Lake | 351 | |
| Los Angeles | 389,346 | 389,346 |
| Madera | 405 | |
| Marin | 5,148 | |
| Mariposa | 121 | |
| Mendocino | 1,145 | |
| Merced | 224 | |
| Monterey | 4,645 | |
| Napa | 1,458 | |
| Nevada | 235 | |
| Orange | 114,320 | 114,320 |
| Placer | 1,100 | |
| Riverside | 13,990 | 13,990 |
| Sacramento | 9,504 | |
| San Benito | 95 | |
| San Bernadino | 9,060 | 9,060 |
| San Diego | 2,294 | 2,294 |
| San Francisco | 221 | |
| San Juaquin | 7,792 | |
| San Luis Obispo | 1,739 | |
| San Mateo | 5,231 | |
| Santa Barbara | 380 | 380 |
| Santa Clara | 2,057 | |
| Santa Cruz | 3,196 | |
| Solano | 1,093 | |
| Sonoma | 7,697 | |
| Stanislaus | 3,083 | |
| Sutter | 734 | |
| Tulare | 233 | |
| Tuolumne | 334 | |
| Ventura | 383 | |
| Yolo | 651 | |
| Yuba | 235 | |
| Total lbs MB used | 598,654 | 529,390 |
| Percentage of MB used in Southern (So.) California counties | | 88 |

Table 36. Dissipation of methyl bromide from five houses in Southern California after actively aerated before closing windows[a].

| After 24-hour aeration | | | After 72-hour aeration | |
|---|---|---|---|---|
| Hours | Measured MB (ppm)[b] | | Hours | Extrapolated MB (ppm)[c] |
| 3.000 | 1.325 | | 49.000 | 0.564 |
| 4.000 | 0.115 | | 50.000 | 0.554 |
| 5.000 | 1.005 | | 51.000 | 0.543 |
| 6.000 | 1.385 | | 52.000 | 0.533 |
| 13.000 | 0.580 | | 53.000 | 0.523 |
| 17.000 | 0.353 | | 54.000 | 0.513 |
| 18.000 | 0.505 | | 55.000 | 0.504 |
| 20.000 | 1.740 | | 56.000 | 0.494 |
| 24.000 | 0.400 | | 57.000 | 0.485 |
| 27.000 | 0.243 | | 58.000 | 0.476 |
| 28.000 | 0.135 | | 59.000 | 0.467 |
| 31.000 | 0.195 | | 60.000 | 0.458 |
| 37.000 | 0.620 | | 61.000 | 0.450 |
| 40.000 | 0.765 | | 62.000 | 0.441 |
| 41.000 | 0.325 | | 63.000 | 0.433 |
| 44.000 | 0.250 | | 64.000 | 0.425 |
| 46.000 | 0.345 | | 65.000 | 0.417 |
| 48.000 | 0.335 | | 66.000 | 0.409 |
| 50.000 | 0.590 | | 67.000 | 0.402 |
| 52.000 | 0.140 | | 68.000 | 0.394 |
| 54.000 | 0.145 | | 69.000 | 0.387 |
| 62.000 | 0.380 | | 70.000 | 0.380 |
| 65.000 | 0.565 | | 71.000 | 0.372 |
| 66.000 | 0.120 | | 72.000 | 0.365 |
| 67.000 | 0.095 | | 73.000 | 0.359 |
| 69.000 | 0.225 | | 74.000 | 0.352 |
| 71.000 | 0.175 | | 75.000 | 0.345 |
| 73.000 | 0.405 | | 76.000 | 0.339 |
| 78.000 | 0.085 | | 77.000 | 0.333 |
| 85.000 | 0.170 | | 78.000 | 0.326 |
| 88.000 | 0.190 | | 79.000 | 0.320 |
| 92.000 | 0.070 | | 80.000 | 0.314 |
| | | | 81.000 | 0.308 |
| | | | 82.000 | 0.303 |
| | | | 83.000 | 0.297 |
| | | | 84.000 | 0.291 |
| | | | 85.000 | 0.286 |
| | | | 86.000 | 0.281 |
| | | | 87.000 | 0.275 |
| | | | 88.000 | 0.270 |

Table 36 (cont. 1). Dissipation of methyl bromide from five houses in Southern California after actively aerated before closing windows[a].

| After 72-hour aeration | | | After 72-hour aeration | |
|---|---|---|---|---|
| Hours | Measured MB (ppm)[b] | | Hours | Extrapolated MB (ppm)[c] |
| 89.000 | 0.265 | | 129.000 | 0.125 |
| 90.000 | 0.260 | | 130.000 | 0.122 |
| 91.000 | 0.255 | | 131.000 | 0.120 |
| 92.000 | 0.251 | | 132.000 | 0.118 |
| 93.000 | 0.246 | | 133.000 | 0.116 |
| 94.000 | 0.241 | | 134.000 | 0.113 |
| 95.000 | 0.237 | | 135.000 | 0.111 |
| 96.000 | 0.232 | | 136.000 | 0.109 |
| 97.000 | 0.228 | | 137.000 | 0.107 |
| 98.000 | 0.224 | | 138.000 | 0.105 |
| 99.000 | 0.220 | | 139.000 | 0.103 |
| 100.000 | 0.215 | | 140.000 | 0.101 |
| 101.000 | 0.211 | | 141.000 | 0.099 |
| 102.000 | 0.207 | | 142.000 | 0.098 |
| 103.000 | 0.204 | | 143.000 | 0.096 |
| 104.000 | 0.200 | | 144.000 | 0.094 |
| 105.000 | 0.196 | | 145.000 | 0.092 |
| 106.000 | 0.192 | | 146.000 | 0.090 |
| 107.000 | 0.189 | | 147.000 | 0.089 |
| 108.000 | 0.185 | | 148.000 | 0.087 |
| 109.000 | 0.182 | | 149.000 | 0.085 |
| 110.000 | 0.178 | | 150.000 | 0.084 |
| 111.000 | 0.175 | | 151.000 | 0.082 |
| 112.000 | 0.172 | | 152.000 | 0.081 |
| 113.000 | 0.169 | | 153.000 | 0.079 |
| 114.000 | 0.165 | | 154.000 | 0.078 |
| 115.000 | 0.162 | | 155.000 | 0.076 |
| 116.000 | 0.159 | | 156.000 | 0.075 |
| 117.000 | 0.156 | | 157.000 | 0.073 |
| 118.000 | 0.153 | | 158.000 | 0.072 |
| 119.000 | 0.151 | | 159.000 | 0.071 |
| 120.000 | 0.148 | | 160.000 | 0.069 |
| 121.000 | 0.145 | | 161.000 | 0.068 |
| 122.000 | 0.142 | | 162.000 | 0.067 |
| 123.000 | 0.140 | | 163.000 | 0.066 |
| 124.000 | 0.137 | | 164.000 | 0.064 |
| 125.000 | 0.134 | | 165.000 | 0.063 |
| 126.000 | 0.132 | | 166.000 | 0.062 |
| 127.000 | 0.129 | | 167.000 | 0.061 |
| 128.000 | 0.127 | | 168.000 | 0.060 |

Table 36 (cont. 2). Dissipation of methyl bromide from five houses in Southern California after actively aerated before closing windows[a].

| After 72-hour aeration | | | After 72-hour aeration | |
|---|---|---|---|---|
| Hours | Measured MB (ppm)[b] | | Hours | Extrapolated MB (ppm)[c] |
| 169.000 | 0.059 | | 193.000 | 0.037 |
| 170.000 | 0.057 | | 194.000 | 0.037 |
| 171.000 | 0.056 | | 195.000 | 0.036 |
| 172.000 | 0.055 | | 196.000 | 0.035 |
| 173.000 | 0.054 | | 197.000 | 0.035 |
| 174.000 | 0.053 | | 198.000 | 0.034 |
| 175.000 | 0.052 | | 199.000 | 0.033 |
| 176.000 | 0.051 | | 200.000 | 0.033 |
| 177.000 | 0.050 | | 201.000 | 0.032 |
| 178.000 | 0.049 | | 202.000 | 0.031 |
| 179.000 | 0.049 | | 203.000 | 0.031 |
| 180.000 | 0.048 | | 204.000 | 0.030 |
| 181.000 | 0.047 | | 205.000 | 0.030 |
| 182.000 | 0.046 | | 206.000 | 0.029 |
| 183.000 | 0.045 | | 207.000 | 0.029 |
| 184.000 | 0.044 | | 208.000 | 0.028 |
| 185.000 | 0.043 | | 209.000 | 0.028 |
| 186.000 | 0.043 | | 210.000 | 0.027 |
| 187.000 | 0.042 | | 211.000 | 0.027 |
| 188.000 | 0.041 | | 212.000 | 0.026 |
| 189.000 | 0.040 | | 213.000 | 0.026 |
| 190.000 | 0.039 | | 214.000 | 0.025 |
| 191.000 | 0.039 | | 215.000 | 0.025 |
| 192.000 | 0.038 | | 216.000 | 0.024 |

[a] locations of fumigated houses: 1) Downey, LA, CA. (Application date 4/7/92)
2) Long Beach, LA, CA. (Application date 4/7/92)
3) Downey, LA, CA (Application date 4/7/92)
4) Downey, LA, CA. (Application date 4/7/92)
5) Walnut, LA, CA. (Application date 4/7/92)
application rate was 1.5 lb/1,000 $ft^3$.

[b] MB concentrations after fumigated houses were actively aerated for 24 hours.

[c] MB concentrations during the 7-day reentry period after active aeration for 3 days.

Table 37. MB concentrations in fumigated houses after a 72-hour aeration period (9).

| Regions of California | Fumigation rate (Lbs MB/1,000 $ft^3$) | MB concentrations (ppb, 24-hour TWA) Day 1 (mean) | Days 1-7, mean ± STDEV (range) |
|---|---|---|---|
| Southern | 1.5 | ≤ 210* | 86 ± 73 (15 - 229) |
| Northern | 3.0 | ≤ 210* | 172 ± 147 (30 - 458) |

* based on the target level of 210 ppb (Nelson, 1992)

10. Exposure of residents to methyl bromide during commodity fumigation.

During commodity fumigation and aeration periods, leaks and offgassing with subsequent dilution can aid in dispersion of MB vapor into the surrounding areas. Residents who live at or beyond an established buffer zone may be exposed to airborne MB. The following assumptions were used to estimate exposure of residents to airborne residues of MB from commodity fumigation.

1. Residents live at an established buffer zone. We did not attempt to estimate exposure of residents beyond the buffer zone.

2. The wind blows continually from the fumigation areas toward residential areas in the same direction. This represents an extreme exposure scenario.

3. Residents are assumed to be exposed to MB at the target level of 210 ppb calculated as the 24-hour TWA (Nelson, 1992).

4. The housing structure does not provide protection from inhalation exposure to MB.

5. There are intermittent fumigations of chambers in those areas contributing to exposure days of more than approximately 30% of days in a 7-day, 90-day or 365-day period. These exposures constitute subacute, subchronic and chronic exposures, respectively (Sanders, 1998). Likewise, if exposure days are less than the specified exposure frequency, there will be no subacute, subchronic and chronic exposures. Also, more frequent MB fumigations in those areas will result in maintaining the target exposure level at or close to the target level of 210 ppb.

The low and high range of exposure days for workers during commodity fumigations were adopted from Haskell (1998a, 1998b) for use in the estimation of residential exposure. Subacute, subchronic and chronic exposures are shown in Table 38.

Table 38. Exposure of residents to airborne methyl bromide during commodity fumigation[a] (10).

| Range of exposure | Subacute exposure /7days | MB (ppb) | Subchronic exposure /90 days | MB (ppb) | Chronic exposure /365 days | MB (ppb) |
|---|---|---|---|---|---|---|
| Low[b] | 3 | 90 | 30 | 70 | 150 | 86 |
| High[b] | 6 | 180 | 75 | 175 | 185 | 106 |

[a] assumed residents are exposed to the target level of 210 ppb (24-hour TWA).

[b] exposure days per 7, 90, and 365 days were assumed to be the same as those for workers during commodity fumigation as indicated by Haskell (1998a, 1998b). The low and high ranges of exposures represent the low and high exposure days of each exposure category, which were employed from various commodity fumigations.

Figure 1. First order dissipation of methyl bromide from five southern California houses after actively aerated for 24 hours before closing windows

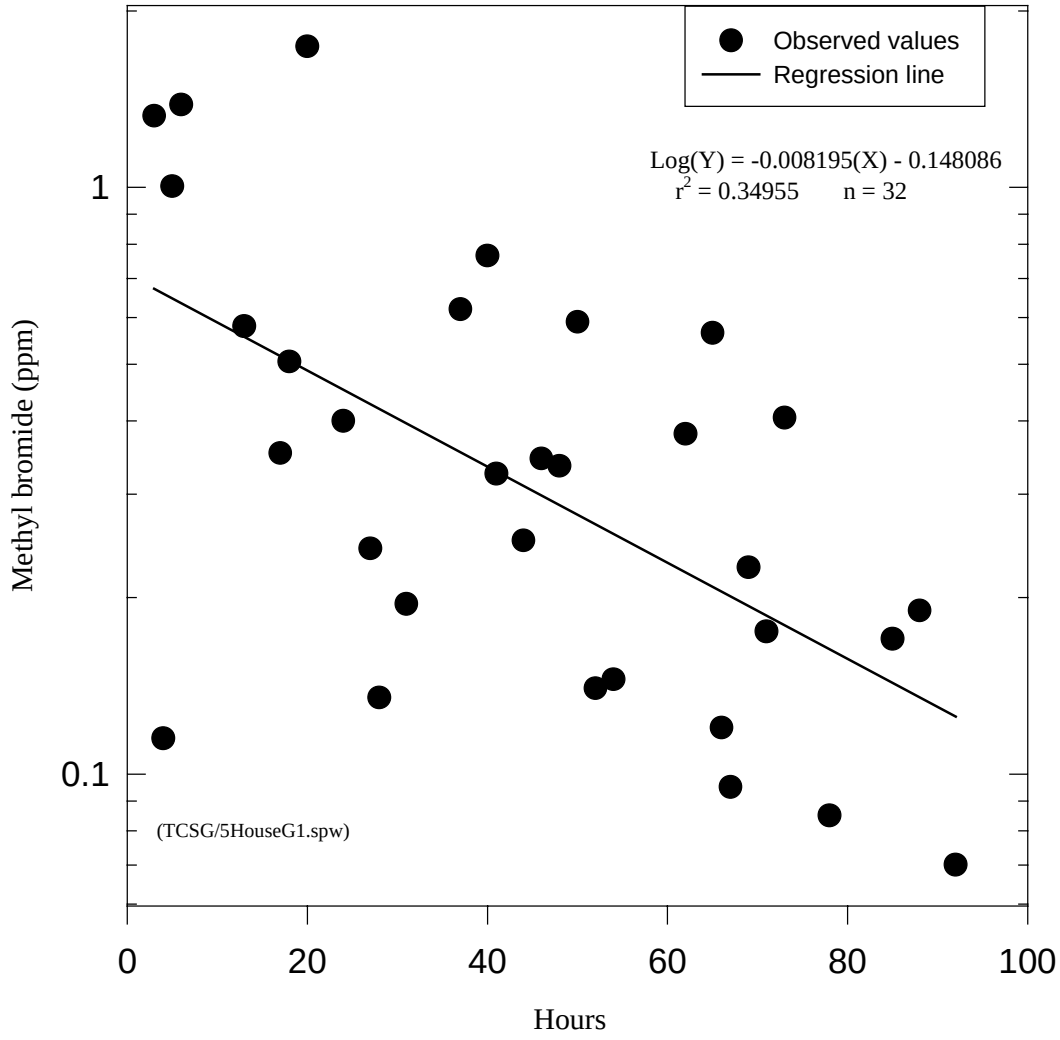
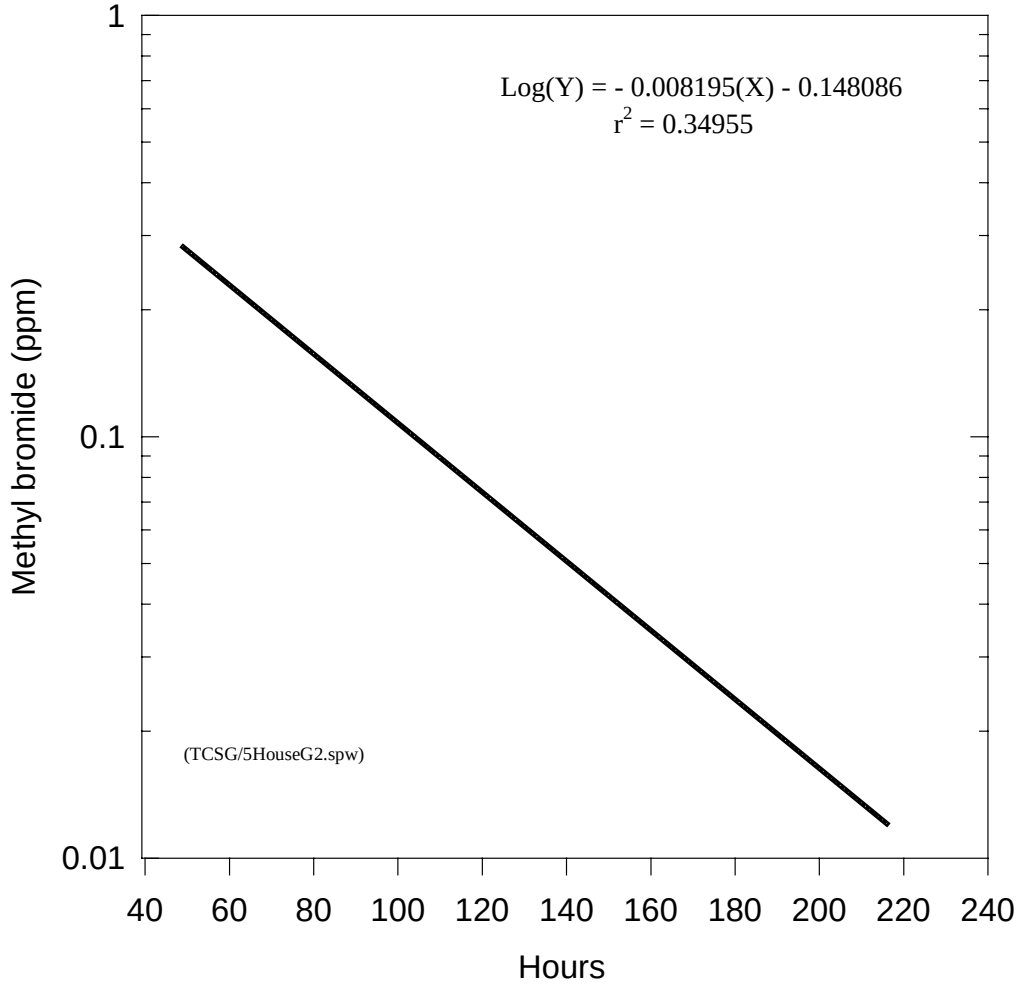


Figure 2. First order dissipation of methyl bromide from five southern California houses after actively aerated for 72 hours before closing windows



## Appendix D
## Exposure of residents to MB from living near fumigated fields

The potential for subchronic exposure of residents to MB from living near fumigated fields was evaluated by Sally Powell of DPR. The attached memoranda of July 31, 1998 and December 16, 1998 demonstrated procedures employed in the evaluation. Basically, the evaluation relied on MB use report data in 1995. The evaluation focused on the peak 3-month use period in four high use counties. Frequency distribution of exposure days (defined as days when gas may be present in the air) was obtained during that use period.

Results from this evaluation indicated that some sections in those counties would have MB gas present for 30 or more days during the 90-day period. However, a quantitative determination of the exposure cannot be made at this time.

The acute exposure level for residents living near fumigated fields was assumed to be 210 ppb, which is the current regulatory level used to determine the buffer zone distance in the DPR permit conditions.

Peter M. Rooney
*Secretary for Environmental Protection*

# Department of Pesticide Regulation

James W. Wells, Director
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Pete Wilson
*Governor*

M E M O R A N D U M

TO: John Ross, Senior Toxicologist
Worker Health and Safety Branch
Department of Pesticide Regulation

FROM: Sally Powell, Senior Environmental Research Scientist
Worker Health and Safety Branch

DATE: July 31, 1998

SUBJECT: EVALUATION OF POTENTIAL SUBCHRONIC EXPOSURE TO METHYL BROMIDE USING PESTICIDE USE REPORT DATA

---

As you requested, I evaluated the potential for subchronic (defined as at least 30 days in any 90-day period) exposure to methyl bromide, using a dataset provided by Bruce Johnson and Yihua Lin of EMPM. Yihua extracted PUR data on methyl bromide applications, excluding commodity and structural fumigations, in the four counties with the greatest total pounds applied in 1995. For each of those counties they selected the three consecutive calendar months accounting for the greatest proportion of total use in the county that year.

*Offsite exposure*

Offsite exposure was evaluated on a section-by-section basis. The top four counties and peak 3-month periods were Fresno (Oct.-Dec.), Kern (July-Sept.), Monterey (Sept.-Nov.) and Ventura (July-Sept.). A total 1137 applications were made in 366 sections during the peak periods in these four counties. In 49 sections (13%), 6 or more applications were made during the peak period.

Frequency distribution of methyl bromide applications per section (peak 3-month period in 1995).

| Number of applications | *freq* | Number of applications | *freq* |
|---|---|---|---|
| 1 | 153 | 11 | 2 |
| 2 | 59 | 12 | 4 |
| 3 | 46 | 13 | 2 |
| 4 | 34 | 14 | 1 |
| 5 | 25 | 15 | 1 |
| 6 | 9 | 17 | 1 |
| 7 | 13 | 18 | 1 |
| 8 | 6 | 20 | 1 |
| 9 | 5 | 29 | 1 |
| 10 | 2 | | |

I estimated the number of exposure days per section by using the actual dates of applications in the 74 sections having at least 5 applications, and assuming that methyl bromide gas would be present for 7 days following each application. Treated fields must be under tarps for 5 days according to current permit conditions. No off-gassing interval has been agreed upon for methyl bromide, but gas does escape during the time the field is tarped, and it can reasonably be expected to escape for at least 2 more days after tarp removal.

Exposure days in peak 3-month use period.

| Number of days | *freq* |
|---|---|
| < 20 | 20 |
| 20 - 24 | 16 |
| 25 - 29 | 9 |
| 30 - 34 | 13 |
| 35 - 39 | 4 |
| 40 - 44 | 4 |
| 45 - 49 | 2 |
| 50 - 69 | 5 |
| 90 | 1 |

Of 29 sections having 30 or more exposure days in the 3-month period, 17 were in Monterey County, 9 in Ventura, 3 in Fresno and none in Kern County.

These numbers suggest that we should pursue the assessment of subchronic offsite exposure in Monterey County, and possibly in Ventura County as well. If a distribution of seasonal average concentrations in ambient air for the 17 sections can be developed, the exposure assessment can be done using the program previously used for 1,3-dichloropropene. Bruce Johnson has told me that it would be possible to develop the distribution using the ISCST3 model, although it would be a lot of work and require quite a bit of time.

*Applicator exposure*

The PUR database does not include the applicator identification number (only the grower i.d. for the owner of the treated property). It cannot, therefore, be used to evaluate potential exposure to individual applicators. The use reports themselves do include the applicator i.d., so the information could be obtained by going to the individual counties, searching through the paper files and hand-tabulating information. This would be a great deal of work, which I do not think would be justified, since the applicator i.d. number pertains to a company and thus is only a surrogate for identifying individual persons.

In order to find out about individual exposures, we will probably have to go to the pest control operators. Apparently, Tri-Cal is doing most of the methyl bromide field applications now, so it could be relatively easy to obtain the information. Monterey County had the greatest number of applications, 521 between September and November 1995. The fact that one company is doing most of the applications makes it likely that individual applicators will have more than 30 days of exposure. I suggest that we try to get Tri-Cal's employee records from Monterey County for September through November of last year.

Peter M. Rooney
*Secretary for Environmental Protection*

# Department of Pesticide Regulation

James W. Wells, Director
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Pete Wilson
*Governor*

M E M O R A N D U M

TO: John Ross, Senior Toxicologist
Worker Health and Safety Branch
Department of Pesticide Regulation

FROM: Sally Powell, Senior Environmental Research Scientist
Worker Health and Safety Branch

DATE: December 16, 1998

SUBJECT: ADDENDUM TO MEMORANDUM TO JOHN ROSS DATED JULY 31, 1998, RE: EVALUATION OF POTENTIAL SUBCHRONIC EXPOSURE TO METHYL BROMIDE USING PESTICIDE USE REPORT DATA

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This is an addendum to the evaluation of potential offsite subchronic exposure to methyl bromide reported in my July 31 memo to you (attached). In that evaluation I estimated the number of exposure days (defined as days when gas may be present in the air) per section for the 74 sections with 5 or more applications within a 3-month peak use period in 1995. The number was calculated using the dates of the actual applications and assuming that methyl bromide gas would be present for 7 days after each application. Seven days of off-gassing were assumed because permit conditions require most treated fields to be under tarps for 5 days. Gas is known to escape during the time a field is tarped, so at a minimum gas is expected to be present during 5 days. It can reasonably be expected that gas will continue to escape for at least 2 more days after tarp removal, but because no off-gassing interval has been agreed upon for methyl bromide, I have included in this memo the number of exposure days under 5- and 6-day off-gassing assumptions as well as 7 days.

It should be noted that these estimates have a bias toward being too low. Randy Segawa pointed out that the number of application days reported in the PUR understates the actual number for strawberry fields in Monterey County. This is due to the current practice of spreading the treatment of a single field over several days in order to satisfy permit restrictions; because only one field is involved, only

one application date is reported. More than half the sections with 30 or more exposure days are in Monterey County (under any off-gassing assumption), and in September-November 1995, 85 % of the agricultural applications of methyl bromide in that county were to strawberries.

Frequency distribution of exposure days per section during peak 3-month use periods in 74 sections with five or more applications in 1995.

| Number of days gas is present | Assumed off-gassing interval (days) | | |
|---|---|---|---|
| | 5 | 6 | 7 |
| | ---------- *freq* ---------- | | |
| < 20 | 37 | 29 | 20 |
| 20 - 24 | 15 | 14 | 16 |
| 25 - 29 | 8 | 14 | 10 [a] |
| 30 - 34 | 5 | 4 | 12 [b] |
| 35 - 39 | 1 | 4 | 5 [c] |
| 40 - 44 | 5 | 2 | 3 [d] |
| 45 - 49 | 0 | 4 | 2 |
| 50 - 69 | 2 | 2 | 5 |
| 76 | 1 | | |
| 86 | | 1 | |
| 93 | | | 1 |

[a, b, c, d] In the original memo, these values were erroneously reported as 9, 13, 4 and 4, respectively.

Thus, depending on the off-gassing interval, 14, 17 or 28 sections would have methyl bromide gas present for 30 or more days during the 90-day period.

Attachment: Memo to John Ross from Sally Powell dated July 31, 1998